Supplemental Information to

***Archaebalaenoptera eusbioi*, a new rorqual from the late Miocene of Peru (Cetacea, Mysticeti, Balaenopteridae) and its impact in reconstructing body size evolution, ecomorphology and palaeobiogeography of Balaenopteridae**

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**Character list for phylogenetic analysis**

The following character list is developed from the morphological dataset of *Bisconti et al. (2019)*. In the present dataset, selected character states were commented in order to warrant clear understanding. In defining character states, we made use of personal observations on specimens listed above and of literature. In particular, we need to cite the following papers that we used for character definitions and codings: Boessenecker & Fordyce (2015); Fordyce & Marx (2012); Steeman (2009); Geisler & Sanders (2003); Kimura & Ozawa (2001); Benke (1993); Kellogg (1923); Miller (1925).

**ROSTRUM: PREMAXILLA, MAXILLA, NASAL**

**1) Rostrum length:**

(0) Rostrum length shorter or equal to neurocranium length;

(1) Rostrum length longer than neurocranium length.

**2) Rostrum width:**

*Comment: character coded 0 in archaeocetes and Balaenidae; all other mysticetes are coded 1.*

(0) Rostrum narrow;

(1) Rostrum wide.

**3) Rostrum straight:**

*Comment: character coded 1 only in Balaenidae and Eschrichtiidae.*

(0) Yes;

(1) No, rostrum highly arched.

**4) Rostrum arc:**

*Comment: character coded for Balaenidae only; code 0 is for* Balaena *and* Balaenella*; code 1 is for* Eubalaena *and* Balaenula.

(0) Continuous;

(1) Discontinuous.

**5) Mesorostral groove:**

(0) Absent;

(1) Present.

**6) Ventral keel along rostrum:**

(0) Absent;

(1) Present.

**7) Premaxilla widens at anterior end:**

(0) No;

(1) Yes.

**8) Premaxillary foramen:**

(0) Present;

(1) Absent.

**9) Posterior end of premaxilla:**

(0) More anterior than frontonasal suture;

(1) At posterior end of nasal;

(2) Anterior to nasal.

**10) Sutural contact between rostrum and frontal limited to ascending process of the maxilla:**

(0) No;

(1) Yes.

**11) Premaxilla and frontal articulation:**

(0) Sutured;

(1) Not sutured.

**12) External surface of maxilla:**

(0) Sub-vertical;

(1) Sub-horizontal.

**13) Medial border of maxilla anterior to narial fossa:**

(0) Straight;

(1) Sinuous.

**14) Lateral border of maxilla:**

(0) Uniformly concave;

(1) Straight;

(2) Uniformly convex;

(3) Sinuous

**15) Thickness of lateral border of maxilla:**

*Comment: Chaeomysticeti and Eomysticetidae are coded 1 when rostrum is preserved.*

(0) Thin;

(1) Thick.

**16) Lateral process of maxilla:**

(0) Absent;

(1) Present.

**17) Length of lateral process of maxilla:**

*Comment: a very long lateral process of the maxilla is observed in those taxa where this structure is longer than the transverse diameter of the maxilla at the level of the antorbital notch; a long lateral process is observed in those taxa where this structure is longer 50% of the transverse diameter of the maxilla at the level of the antorbital notch but is shorter than the whole transverse diameter.*

(0) Short;

(1) Long.

(2) Very long.

**18) Position of external apex of lateral process of maxilla:**

(0) Anterior to antorbital corner of orbit;

(1) Anterior and medial to orbit.

**19) Infraorbital process of maxilla:**

(0) Absent;

(1) Present.

**20) Ascending process of maxilla:**

(0) Absent;

(1) Present.

**21) Width of ascending process of maxilla relative to its length:**

(0) Narrow;

(1) Wide.

**22) Length of ascending process of maxilla:**

*Comment: Balaenidae, Neobalaenidae and basal thalassotherian taxa are coded 0; Eschrichtiidae, Cetotheriidae and Balaenopteridae are coded 1.*

(0) Short;

(1) Long;

**23) Lateral border of ascending process of maxilla:**

(0) Forms an evident corner with posterior border of maxilla;

(1) Forms a wide curve with posterior border of maxilla.

**24) Position of posterior ends of ascending processes of maxillae:**

(0) Posterior ends do not meet along midline;

(1) Posterior ends meet along midline.

**25) Meeting of ascending processes of the maxillae along the longitudinal axis of the skull:**

(0) Contact limited to posterior corners;

(1) Contact extended to most of medial borders of the ascending processes of the maxillae.

**26) Shape of posterior end of ascending process of maxilla at adulthood:**

(0) Triangular;

(1) Squared;

(2) Rounded.

**27) Shape of posterior end of ascending process of maxilla during late ontogeny:**

(0) Triangular;

(1) Squared;

(2) Rounded.

**28) Lateral and medial borders of ascending process of maxilla:**

(0) Anteriorly diverging;

(1) Parallel;

(2) Anteriorly converging.

**29) Position of posterior end of maxilla:**

(0) Anterior to nasal;

(1) At level of posterior end of nasal;

(2) Posterior to nasal.

**30) Position of posterior ends of maxillae:**

*Comment: posterior ends of maxillae are transversely far if the nasals and premaxillae have wide transverse diameter. For instance, state 0 is present in living* Balaenoptera *species and in Balaenidae; state 0 is present in early-diverging balaenopterids such as* Protororqualus *and in basal thalassotherian taxa where the transverse diameter of the nasals is massively shortened; state 2 is present in Cetotheriidae.*

(0) Transversely far;

(1) Transversely close;

(2) Transversely very close.

**31) Numerous dorsal infraorbital foramina:**

(0) Absent (only one foramen is present);

(1) Present.

**32) Location of dorsal infraorbital foramina:**

(0) Scattered along dorsal surface of maxilla;

(1) Mostly located close to the medial border of maxilla.

**33) Medial border of maxilla:**

(0) not relieved;

(1) relieved and forming a crest.

**34) Antorbital notch:**

(0) Absent;

(1) Present.

**35) Shape of antorbital notch:**

(0) Concavity in anterior edge of lateral process of maxilla without medial-projecting groove;

(1) Developed along medial-projecting groove.

**36) Articulation between maxilla and frontal:**

(0) Tight;

(1) Loose.

**37) Maxillary pocket:**

(0) Absent;

(1) Present.

**38) Infraorbital plate visible in dorsal view:**

(0) No;

(1) Yes.

**39) Teeth at adulthood in maxilla and premaxilla:**

(0) Present;

(1) Absent.

**40) Grooves for vasculature of baleen epithelium:**

(0) Absent;

(1) Present.

**41) Fissure located along posterior border of maxilla in ventral view:**

(0) Absent;

(1) Present.

**42) Elongation of fissure:**

*Comment: character coded in Balaenidae and Neobalaenidae only; state 0 is present in Neobalaenidae; state 1 is present in Balaenidae.*

(0) Fissure short;

(1) Fissure long.

**43) Nasal length:**

(0) Nasal reaching the anterior 20% of rostrum;

(1) Nasal reaching approximately rostrum midlength;

(2) Nasal reaching the posterior 20% of rostrum;

(3) Nasal reaching a point close to the anterior border of the supraorbital process of frontal.

(4) Nasal reaching a point located within the interorbital region of the frontal.

**44) Anterior border of nasal:**

(0) Concave;

(1) Straight;

(2) Convex.

**45) Median keel in nasal:**

(0) Absent;

(1) Present.

**46) Position of anterolateral corner of nasal:**

(0) Anterior to anteromedial corner;

(1) Lateral to anteromedial corner;

(2) Posterior to anteromedial corner.

**47) Position of frontonasal suture:**

(0) At anterior border of interorbital region of frontal;

(1) Well within interorbital region of frontal.

**48) Nasal borders:**

(0) With a concavity at midlength

(1) Converging anteriorly;

(2) Parallel-to-subparallel;

(3) Diverging anteriorly.

**49) Nasal width:**

(0) Nasal transversely wide;

(1) Nasal with strong transverse compression along its entire length.

**FRONTAL**

**50) Shape of supraorbital process of frontal:**

(0) Flat and forming a dorsal shield;

(1) descending from interorbital region of frontal;

**51) Diversity of depressions:**

(0) No depression;

(1) Gentle depression from interorbital region of frontal;

(2) Abrupt depression from interorbital region of frontal;

**52) Cross-sections of depressions:**

(0) No depression;

(1) Triangular;

(2) Laterally concave;

(3) Squared;

(4) Half-circle.

**53) Anteroposterior length of supraorbital process of frontal:**

*Comment: very long anteroposterior length of the supraorbital process of the frontal is observed in Balaenopteridae; a long anteroposterior length is observed in Eschrichtiidae and some Cetotheriidae while all the other mysticetes are coded 0.*

(0) Short;

(1) Long;

(2) Very long.

**54) Transverse diameter of supraorbital process of frontal with respect to length of neurocranium:**

*Comment: a short diameter of supraorbital process of frontal with respect to the length of neurocranium is observed in archaeocetes and and early toothed mysticetes; state 1 is observed in Eomysticetidae, basal thalassotherian taxa, neobalaenids and some cetotheriids; state 2 is observed in Balaenidae and Balaenopteridae.*

(0) Short;

(1) Long;

(2) Very long.

**55) Anterior border of supraorbital process of frontal:**

(0) Directed posteriorly;

(1) Directed transversely;

(2) Directed anteriorly.

**56) Anterior border of supraorbital process of frontal:**

(0) Straight;

(1) Convex;

(2) Concave.

**57) Backing of central and distal portions of the anterior border of the supraorbital process of frontal from its anteromedial corner:**

(0) Absent;

(1) Present.

**58) Posterior border of supraorbital process of frontal:**

(0) Uniformly concave;

(1) Medial concavity;

(2) Straight.

**59) Posterior border of supraorbital process of frontal:**

(0) Directed posteriorly;

(1) Directed transversely;

(2) Directed anteriorly.

**60) Supraorbital foramina:**

(0) Present;

(1) Absent.

**61) Orbitotemporal crest:**

(0) Along posterodorsal edge of supraorbital process of frontal;

(1) From postorbital corner to anteromedial end of supraorbital process of frontal;

(2) Forming a curve from postorbital corner onto dorsal surface of supraorbital process of frontal;

(3) Forming a curve along anterior edge of supraorbital process of frontal.

**62) Orbitotemporal crest:**

(0) Well developed and sharp;

(1) Well developed and rounded;

(2) Highly reduced to a line.

**63) Superimposition of parietal on interorbital region of frontal:**

(0) Absent;

(1) Present.

**64) Long superimposition of posteromedial elements of rostrum on interorbital region of frontal:**

(0) Absent;

(1) Present.

**65) Posterior border of interorbital region of frontal:**

(0) In contact with parietal;

(1) In contact with supraoccipital.

**66) Shape of coronal (frontal-parietal) suture:**

(0) Straight;

(1) Anteriorly convex;

(2) Anteriorly concave.

**67) Coronal suture in dorsal view:**

(0) Visible;

(1) Not visible because superimposed by the supraoccipital.

**68) Frontal encircles ascending process of maxilla:**

(0) No;

(1) Yes.

**69) Postorbital process and zygomatic process of squamosal:**

*Comment: state 0 is observed in those taxa where there is a long space between the anterior end of the zygomatic process of the squamosal and the postorbital process. State 1 is observed in those taxa where the space between the zygomatic process and the postorbital process is strongly reduced and these structures are almost in contact.*

(0) Far;

(1) Close;

(2) Superimposed and articulated by dedicate facet.

**70) Location of optic canal in ventral surface of supraorbital process of frontal:**

(0) Along anterior three-fourth;

(1) Along posterior one-fourth.

**71) Length of intertemporal constriction:**

*Comment: state 0 is observed in archaeocetes and Eomysticetidae; state 1 is observed in basal thalassotherian taxa; state 2 is observed in Cetotheriidae and Eschrichtiidae; state 3 is observed in Balaenidae, Neobalaenidae and Balaenopteridae.*

(0) Very long;

(1) Long;

(2) Short;

(3) Very short.

**72) Transverse diameter of intertemporal constriction:**

*Comment: state 0 is observed in archaeocetes and eomysticetiids; state 1 is observed in basal thalassotherian taxa and cetotheriids; state 2 is observed in balaenids, neobalaenids, eschrichtiids and balaenopterids.*

(0) Highly constricted;

(1) Moderately constricted;

(2) Wide.

**73) Presence of narial process:**

(0) Present;

(1) Absent.

**74) Length of narial process relative to nasal length:**

*Comment: the narial process is coded 0 if the anteroposterior length is less than the transverse width and 1 if the anteroposterior length is longer or equal to the transverse width;*

(0) Short;

(1) Long.

**75) Shape of narial process:**

(0) The narial processes form a triangle in dorsal view;

(1) The narial processes form a bilobated protrusion in dorsal view.

**PARIETAL**

**76) Location of frontal border of parietal:**

(0) Posterior to posterior apex of ascending process of maxilla;

(1) Anterior to posterior apex of ascending process of maxilla.

**77) Anterolateral corner of parietal (for Balaenidae only):**

(0) Sharp;

(1) Broad.

**78) Anterior portion of external surface along wall of temporal fossa:**

(0) Visible in dorsal view;

(1) Not visible in dorsal view because overhanged by temporal crest.

**79) Posterior portion of external surface:**

(0) Visible in dorsal view;

(1) Not visible in dorsal view because overhanged by temporal crest.

**80) Post-parietal foramen:**

(0) Present;

(1) Absent.

**81) Parietal spreading onto emergence of supraorbital process of frontal:**

(0) Absent;

(1) Present.

**82) Parietal exposed at cranial vertex:**

(0) Yes;

(1) No.

**83) Length of parietal exposure at vertex:**

*Comment: state 0 is observed in archaeocetes, Eomysticetidae; state 1 is observed in basal thalassotherian taxa; state 2 is observed in Cetotheriidae and Eschrichtiidae; state 3 is observed in Balaenopteridae.*

(0) Long;

(1) Moderate;

(2) Short;

(3) Very short.

**84) Sagittal crest at cranial vertex:**

(0) Present;

(1) Absent.

**85) Attach for temporalis muscle at intertemporal constriction:**

*Comment: state 0 corresponds to a transversely narrow sagittal crest; state 1 corresponds to a sagittal crest with expanded dorsal surface (as observed, for instance, in Titanocetus sammarinensis); state 2 is observed in Cetotheriidae and Eschrichtiidae; state 3 is observed in Balaenopteridae, Balaenidae and Neobalaenidae.*

(0) Very narrow;

(1) Slightly widened;

(2) Moderately widened;

(3) Wide.

**86) Shape of sagittal crest:**

(0) Sharply-edged;

(1) Forming two opposite concavities.

**87) Tubercle at lambdoid suture:**

(0) Absent;

(1) Present.

**88) Parietal-squamosal suture:**

(0) Sinuous;

(1) Straight.

**SQUAMOSAL**

**89) Dorsoventral height of squamosal:**

*Comment: high dorsoventral height of squamosal in lateral view is observed only in Balaenidae and Neobalaenidae.*

(0) Low dorsoventral height;

(1) High dorsoventral height.

**90) Anteroposterior length of zygomatic process of squamosal with respect to its height:**

*Comment: a very long zygomatic process of the squamosal is observed in archaeocetes, Aetiocetidae and Eomysticetidae; state 1 is observed in basal thalassotherian taxa and Balaenopteridae; state 2 is observed in Cetotheriidae and Eschrichtiidae; state 3 is observed in Balaenidae and Neobalaenidae.*

(0) Very long;

(1) Long;

(2) Short.

(3) Very short.

**91) Height of zygomatic process of squamosal:**

(0) Zygomatic process higher than postglenoid process;

(1) Zygomatic process at the same level of postglenoid process;

(2) Zygomatic process much higher than postglenoid process.

**92) Projection of anterior portion of zygomatic process of squamosal in dorsal view:**

(0) Projecting anteromedially;

(1) Projecting anterolaterally;

(2) Projecting anteriorly.

**93) Projection of posterior portion of zygomatic process of squamosal in dorsal view:**

(0) Projecting anteromedially;

(1) Projecting anterolaterally

(2) Projecting anteriorly.

**94) Zygomatic process of squamosal in dorsal view:**

(0) Anteriorly straight;

(1) Anteriorly twisted.

**95) Distinctive articular facet for postorbital process of frontal on zygomatic process of squamosal:**

(0) Absent;

(1) Present.

**96) Projection of apex of zygomatic process in lateral view:**

(0) Anterior;

(1) Ventral.

**97) Postglenoid process of squamosal:**

(0) Projecting ventrally;

(1) Projecting posteroventrally.

**98) Twisted postglenoid process of squamosal:**

(0) No;

(1) Yes.

**99) Lateral surface of squamosal:**

(0) Smooth;

(1) With single fossa for sternomastoid muscle;

(2) With double fossa for sternomastoid muscle.

**100) Anteroposterior concavity along dorsolateral edge of glenoid fossa of squamosal:**

(0) Absent;

(1) Present.

**101) Glenoid fossa of squamosal:**

(0) Forming a right angle in lateral view;

(1) Slightly concave;

(2) Highly concave (crescent-shaped);

(3) Straight.

**102) Location of glenoid fossa of squamosal:**

0) posterior to orbit;

1) immediately posteroventral to orbit.

**103) Height of squamosal at nuchal crest:**

(0) Low;

(1) High.

**104) Supramastoid crest:**

(0) Present;

(1) Absent.

**105) Orientation of supramastoid crest:**

(0) Dorsal;

(1) Anterior.

**106) Nuchal crest in dorsal view:**

*Comment: state 0 corresponds to a nuchal crest with wide and round shape; state 1 corresponds to a nuchal crest with round but narrow shape; state 2 corresponds to a triangular nuchal crest.*

(0) Wide;

(1) Narrow;

(2) Very narrow.

**107) Nuchal crest in dorsal view:**

(0) Circular;

(1) Triangular.

**108) Nuchal crest in dorsal view:**

(0) Reaching a point anterior to occipital condyle;

(1) Reaching a point posterior to occipital condyle;

(2) Reaching a point at the same level as occipital condyle.

**109) Squamosal bulging into temporal fossa:**

(0) No;

(1) Yes.

**110) Extension of temporal fossa with respect to total skull length:**

*Comment: state 0 is observed in archaeocetes, Aetiocetidae and Eomysticetidae; state 1 is observed in basal thalassotherian taxa; state 2 is observed in Cetotheriidae, Balaenidae, Neobalaenidae and Balaenopteridae.*

(0) Very wide;

(1) Wide;

(2) Reduced.

**111) Extension of temporal fossa:**

(0) Longer than wide;

(1) Wider than long.

**112) Shape of temporal fossa in dorsal view:**

(0) Oval;

(1) Almond-shaped;

(2) Triangular.

**113) Surface of temporal fossa anterior to nuchal crest:**

(0) More horizontal than ventral-most portion;

(1) Developed dorsoventrally.

**114) Squamosal cleft:**

(0) Absent;

(1) Present.

**115) Shape of squamosal cleft:**

(0) Straight;

(1) Triangular.

**116) Length of squamosal cleft:**

*Comment: state (0) < 50 mm; (1) between 51 and 70 mm; (2) longer than 70 mm.*

(0) Short;

(1) Long;

(2) Very long.

**117) Origin of squamosal cleft at adulthood:**

(0) From parietal-squamosal suture;

(1) From parietal-squamosal-alisphenoid suture;

(2) From squamosal-alisphenoid suture;

(3) From squamosal-pterygoid suture.

**118) Origin of squamosal cleft during late ontogeny:**

(0) From parietal-squamosal suture;

(1) From parietal-squamosal-alisphenoid suture;

(2) From squamosal-alisphenoid suture;

(3) From squamosal-pterygoid suture.

**119) Infundibulum of Foramen ovale:**

(0) Absent;

(1) Present.

**120) Foramen ovale:**

*Comment: definitions of complete and incomplete infundibulum are from Fraser and Purves (1960).*

(0) Infundibulum complete;

(1) Infundibulum incomplete.

**121) Foramen ovale:**

(0) Located within squamosal;

(1) Located between squamosal and pterygoid.

(2) Located within pterygoid.

**122) Suture present in foramen ovale:**

(0) No;

(1) Yes.

**123) Squamosal crease:**

(0) Absent;

(1) Present.

**124) Secondary squamosal crest:**

(0) Absent;

(1) Present.

**125) Secondary squamosal fossa:**

(0) Absent;

(1) Present.

**126) Basicranial foramina:**

(0) Separate foramina in posterolateral portion of skull;

(1) Foramina confluent into a single and large hiatus cranicus.

**SUPRAOCCIPITAL**

**127) Supraoccipital in dorsal view:**

(0) Not visible because main development is dorsoventral;

(1) Visible because it superimposes on parietal.

**128) Anteroposterior supraoccipital elongation:**

(0) No anteroposterior elongation;

(1) Short: supraoccipital superimposed on posterior portion of parietal;

(2) Long: supraoccipital superimposed on most of parietal;

(3) Very long: supraoccipital superimposed on whole parietal and part of interorbital region of frontal.

**129) Anteroposterior supraoccipital elongation with respect to zygomatic process of squamosal:**

(0) Anterior border of supraoccipital reaching a point located more posteriorly than the anterior apex of the zygomatic process of squamosal;

(1) Anterior border of supraoccipital reaching a point located more anteriorly than the anterior apex of the zygomatic process of squamosal.

**130) Shape of anterior border of supraoccipital:**

*Comment: state (3) is observed when a triangular anterior portion of a supraoccipital shows externally convex and rounded borders rather than straight.*

(0) Round;

(1) Triangular;

(2) Squared;

(3) Ogival.

**131) Distinctive articular facets for ascending process of the maxilla in anterior border of supraoccipital:**

(0) Absent;

(1) Present.

**132) Size of anterior border of supraoccipital:**

*Comment: the anterior border of the supraoccipital is wide in archaeocetes and* Titanocetus*.*

(0) Wide;

(1) Pointed;

(2) Narrow.

**133) Elevation of anterior border of supraoccipital in lateral view:**

(0) High elevation formed by dorsal protrusion of parietals lateral and in front of the anterior border of supraoccipital;

(1) Low elevation without contribution by the parietal;

(2) No elevation at all.

**134) Distinctive depression in front to supraoccipital in lateral view:**

(0) Present;

(1) Absent.

**135) Dorsal surface of supraoccipital:**

(0) Concave;

(1) Flat-to convex.

**136) Attach sites for neck muscle attachments:**

(0) Not evident;

(1) Well developed.

**137) Attach sites for neck muscle attachments:**

(0) Shaped as triangular relieves with flat surface;

(1) Shaped as tubercles.

**138) External occipital crest:**

(0) Absent;

(1) Present.

**139) Lateral borders of supraoccipital in dorsal view:**

(0) Not visible;

(1) Uniformly convex;

(2) uniformly straight;

(3) uniformly concave;

(4) sinuous because of the presence of a transverse constriction.

**140) Position of transverse constriction of supraoccipital:**

(0) In anterior-most portion;

(1) At mid-length;

(2) In posterior half.

**141) Degree of transverse constriction with respect to maximum transverse width:**

*Comment: scarce transverse constriction is observed in Eomysticetidae, basal thalassotherian taxa, Cetotheriidae, Eschrichtiidae and* Balaenoptera*; moderate constriction is observed in* Protororqualus *and* Nehalaennia*; strong constriction is observed in* Archaebalaenoptera *and* ‘Balaenoptera’ cortesii *var.* portisi*.*

(0) Scarce;

(1) Moderate;

(2) Strong.

**142) Lateral borders of supraoccipital anterior to the transverse constriction:**

(0) Concave;

(1) Straight-to-convex.

**143) Length of external occipital protuberance:**

*Comment: a short external occipital protuberance is observed in* Protororqualus*; a long external occipital protuberance is observed in* ‘Balaenoptera’ cortesii *var.* portisi*.*

(0) Long;

(1) Moderate;

(2) Short.

**144) Anterolateral corner of supraoccipital:**

(0) Not distinguishable;

(1) Collapsed into a single anterior point;

(2) Rounded;

(3) Squared.

**145) Supraoccipital bent at midlength:**

(0) No;

(1) Yes.

**INTERPARIETAL**

**146) Interparietal:**

(0) Absent;

(1) Present.

**147) Shape of interparietal:**

*Comment: as shown in Wada et al. (2003), in Balaenopteridae, the interparietal may be anteroposteriorly long and transversely narrow and anteroposteriorly short and transversely wide; characters 147 and 148 relate to this observation.*

(0) Short;

(1) Long.

**148) Shape of interparietal:**

(0) Wide;

(1) Narrow.

**JUGAL**

**149) Jugal elongation:**

*Comment: elongated and straight jugal is observed in archaeocetes.*

(0) Jugal elongated and mostly straight;

(1) Jugal short and rounded.

**LACRIMAL**

**150) Lacrimal exposed in dorsal view:**

(0) No;

(1) Yes.

**151) Sutured lacrimal:**

(0) Yes;

(1) No.

**EXOCCIPITAL**

**152) Exoccipital in posterior view:**

(0) Anterolateral border forming a right angle with lateral edge of supraoccipital;

(1) Anterolateral border continuous with lateral edge of supraoccipital.

**153) Exoccipital development in posterior view:**

*Comment: the transverse elongation of the supraoccipital is observed in those taxa where there is a sharp corner between the anterodorsal border of the exoccipital and the posterolateral border of the supraoccipital being the lateral portion of the exoccipital protruded laterally; this character is absent in crown mysticetes and cetotheriids.*

(0) Exoccipital transversely elongated;

(1) Transverse elongation of exoccipital reduced.

**154) Protrusion of posterolateral corner of exoccipital:**

(0) At level of postglenoid process;

(1) Medial to postglenoid process.

**155) Protrusion of posterolateral corner of exoccipital:**

(0) Reaching a point more anterior than occipital condyles;

(1) Reaching a point more posterior than occipital condyles.

**156) Protrusion of posterolateral corner of exoccipital:**

(0) More posterior than postglenoid process of squamosal.

(1) More anterior than postglenoid process of squamosal;

**157) Occipital condyle:**

(0) Convex articular face;

(1) Flat-to-slightly convex articular face.

**158) Neck of occipital condyle:**

(0) Well developed;

(1) Indistinct.

**159) Condyloid foramen:**

(0) Present;

(1) Absent.

**160) Foramen in jugular notch:**

(0) Present;

(1) Absent.

**BASIOCCIPITAL**

**161) Basioccipital crest:**

(0) Absent;

(1) Present.

**162) Fusion of medial crest of basioccipital crest and falcate process of basioccipital:**

(0) Absent;

(1) Present.

**ALISPHENOID**

**163) Alisphenoid exposure in temporal fossa:**

(0) Present;

(1) Absent.

**164) Size of alisphenoid exposure in temporal fossa:**

 (0) Large;

(1) Small;

(2) Very small.

**165) Alisphenoid borders:**

(0) Between frontal, parietal, squamosal and pterygoid;

(1) Between parietal, squamosal and pterygoid;

(2) Between parietal and squamosal;

(3) Between parietal and pterygoid.

**PALATINE**

**166) Palatine reaching a point located close to posterior border of skull:**

(0) No;

(1) Yes.

**PTERYGOID**

**167) Pterygoid fossa:**

(0) Absent;

(1) Present.

**168) Pterygoid hamulus:**

*Comment: well developed pterygoid hamulus is observed only in* Balaenoptera *and* Megaptera*.*

(0) Short;

(1) Well developed.

**169) Ventral lamina of pterygoid:**

(0) Absent;

(1) Present.

**170) Pterygoid exposure in temporal fossa:**

(0) Absent;

(1) Present.

**PERIOTIC**

**171) Posterior process exposure in lateral wall of skull:**

(0) Absent;

(1) Present.

**172) Posterior process length:**

*Comment: a short posterior process is observed in archaeocetes, odontocetes and early-diverging chaeomysticetes (Eomysticetidae); a long posterior process is observed in extant Balaenidae and Balaenopteridae.*

(0) Short;

(1) Moderate;

(2) Long.

**173) Posterior process size and shape:**

(0) Prismatic and robust;

(1) Transversely compressed and flattened.

**174) Facial sulcus along posterior process:**

(0) Absent;

(1) Present.

**175) Facial sulcus along posterior process:**

*Comment: a long facial sulcus is developed along approximately the whole length of the posterior process otherwise it is considered short.*

(0) Short;

(1) Long.

**176) Position of facial sulcus on posterior process:**

(0) Along medial border and hidden in ventral view;

(1) Ventromedial;

(2) Completely ventral.

**177) Borders of facial sulcus:**

(0) Sulcus bordered by crests;

(1) Sulcus widened and bordered by narrow relieves.

**178) Facial sulcus completely included in a tube-like structure:**

(0) No;

(1) Yes.

**179) Shape of posterior border of posterior process:**

(0) Clavate;

(1) Squared;

(2) Pointed.

**180) Stylomastoid fossa:**

(0) Not distinguishable;

(1) Elongated and shallow;

(2) Elongated and covered by a relieved dorsal edge in the posterior process;

(3) Short and included within posterior process as a notch.

**181) Anterior process:**

(0) Absent;

(1) Present.

**182) Anterior process length:**

*Comment: a short anterior process is observed when the anterior process length is less-to-equal to the posterior process length otherwise the anterior process is long.*

(0) Short;

(1) Long.

**183) Anterior process thickness:**

*Comment: a blade-like anterior process is observed in some Cetotheriidae where the anterior process is subtle in medial view; the anterior process is thick in balaenids and in all those taxa where the maximum height of the anterior process is equal-to-longer to the dorsoventral height of the pars cochlearis in medial view otherwise it is thin.*

(0) Thick;

(1) Thin;

(2) Blade-like.

**184) Origin of anterior process:**

(0) Abruptly depressed from dorsal surface of periotic;

(1) Anterior process continuous with dorsal surface of periotic.

**185) Anterior process in dorsal (or ventral) view:**

(0) Squared;

(1) Irregular shape;

(2) Triangular;

(3) Elliptical.

**186) If triangular, medial edge of anterior process:**

(0) Convex or straight;

(1) Concave.

**187) If triangular, lateral edge of anterior process:**

(0) Convex or straight;

(1) Concave.

**188) If triangular, apex of anterior process:**

(0) Round;

(1) Pointed.

**189) Lateral tuberosity:**

(0) Absent;

(1) Present.

**190) Size of lateral tuberosity:**

(0) Small;

(1) Large.

**191) Shape of lateral tuberosity:**

(0) Protruding and squared or rounded;

(1) Protruding and triangular.

**192) Lateral process of anterior process:**

(0) Absent;

(1) Present.

**193) Length of lateral process of anterior process:**

*Comment: the lateral process of the anterior process is long if its apex reaches the mid-length of the posterior process; if it does not reach that point then it is short. This character is coded for Balaenidae.*

(0) Long;

(1) Short.

**194) Shape of lateral process of anterior process:**

(0) Broadly triangular;

(1) Sharply triangular.

**195) Medial emergence of anterior process:**

(0) Absent;

(1) Present.

**196) Tensor tympani groove along anterodorsal edge of pars cochlearis:**

(0) Present;

(1) Absent.

**197) Dorsal surface of periotic:**

(0) Highly relieved;

(1) Low.

**198) Highly relieved dorsal surface of periotic:**

(0) Squared;

(1) Dome-shaped.

**199) Dorsal surface of periotic and anterior process forming a straight line in medial view:**

(0) No;

(1) Yes.

**200) Suprameatal area:**

(0) Concave;

(1) Gently descending;

(2) Convex and protruding.

**201) Superior process:**

(0) Present;

(1) Absent.

**202) Size of superior process:**

(0) Convex dorsal profile in medial view;

(1) Reduced to a low ridge;

(2) Absent.

**203) During late ontogeny, internal acoustic meatus including:**

(0) Tractus spiralis foraminosus, foramen singulare and endocranial opening of facial canal;

(1) Tractus spiralis foraminosus and foramen singulare.

**204) At adulthood, internal acoustic meatus including:**

(0) Tractus spiralis foraminosus, foramen singulare and endocranial opening of facial canal;

(1) Tractus spiralis foraminosus and foramen singulare.

**205) Crista transversa during ontogeny:**

(0) Septum-like;

(1) Thick.

**206) Crista transversa during adulthood:**

(0) Septum-like;

(1) Thick.

**207) Position of crista transversa at adulthood:**

(0) Does not reach medial rim of internal acoustic meatus;

(1) Reaches medial rim of internal acoustic meatus.

**208) Fissure in endocranial opening of facial canal during ontogeny:**

(0) Absent;

(1) Present.

**209) Fissure in endocranial opening of facial canal at adulthood:**

(0) Absent;

(1) Present.

**210) Vascular groove:**

(0) Evident;

(1) Reduced;

(2) Absent.

**211) Transverse elongation of pars cochlearis:**

*Comment: transverse elongation of the pars cochlearis is observed only in Balaenopteridae and Eschrichtiidae.*

(0) Short;

(1) Elongated.

**212) Anteroposterior elongation of pars cochlearis:**

*Comment: anteroposterior elongation of pars cochlearis is observed only in Balaenopteridae and Eschrichtiidae.*

(0) Short;

(1) Elongated.

**213) Inflation of pars cochlearis:**

(0) Absent;

(1) Present.

**214) Anterior crest along pars cochlearis:**

(0) Absent;

(1) Present.

**215) Cochlear window (round window) and aperture for cochlear aqueduct (endolymphatic foramen) confluent during late ontogeny:**

(0) No;

(1) Yes.

**216) Cochlear window (round window) and aperture for cochlear aqueduct (endolymphatic foramen) confluent at adulthood:**

(0) No;

(1) Yes.

**217) Cochlear window (round window) and aperture for cochlar aqueduct (endolymphatic foramen) opening in a tube-like channel:**

(0) No;

(1) Yes.

**218) Promontorial groove:**

(0) Absent;

(1) Present.

**219) Size of promontorial groove:**

*Comment: a large promontorial groove is observed in* Plesiobalaenoptera quarantellii*,* ‘Megaptera’ hubachi *and SAM 55001.*

(0) Small;

(1) Large.

**220) Endocranial opening of facial canal connected to internal acoustic meatus by a groove:**

(0) No;

(1) Yes.

**221) Pyramidal process:**

(0) Present;

(1) Absent.

**TYMPANIC BULLA**

**222) Shape of posterior border:**

(0) Bilobated;

(1) Transversely straight;

(2) Convex;

(3) Keeled.

**223) Elongation of portion posterior to conical process:**

(0) Present;

(1) Absent.

**224) Posterior border fissurated:**

(0) Yes;

(1) No.

**225) Elliptical foramen:**

(0) present;

(1) absent.

**226) Ventral keel:**

(0) Absent;

(1) Present.

**227) Ventral concavity:**

(0) Present;

(1) Absent.

**228) involucral protrusion in dorsal view:**

(0) Absent;

(1) Present.

**229) Dorsal border of involucrum in medial view:**

(0) Gently descending;

(1) Not descending.

**230) Position of Eustachian opening relative to overall height of tympanic bulla:**

*Comment: the Eustachian opening is located more ventrally in early diverging mysticetes including eomysticetids, basal thalassotherian taxa and cetotheriids; in all the other baleen-bearing mysticetes it is located at a higher position.*

(0) Low;

(1) High.

**231) Eustachian opening bordered anteriorly:**

(0) no;

(1) yes.

**232) Flat posterior dorsomedial face:**

(0) No;

(1) Yes.

**233) Anterolateral expansion:**

(0) Absent;

(1) Present.

**234) Extension of anterolateral expansion:**

*Comment: a short anterolateral expansion is observed in Balaenidae and Neobalaenidae.*

(0) Short;

(1) Long.

**235) Shape of anterolateral expansion in dorsal view:**

(0) Round;

(1) Pointed.

**236) Tympanic cavity with respect to length of tympanic cavity:**

*Comment: a low tympanic cavity is observed in Balaenidae and Neobalaenidae only.*

(0) High;

(1) Low.

**237) Height of tympanic bulla:**

*Comment: a low tympanic bulla is observed in Balaenidae and Neobalaenidae only.*

(0) High;

(1) Low.

**238) Anterior border:**

(0) Anteriorly convex;

(1) Anteriorly straight-to-concave.

**239) Sigmoid process:**

(0) Anteroposteriorly elongated;

(1) Transversely elongated.

**240) Conical process:**

(0) High;

(1) Very reduced.

**241) Proportional size of tympanoperiotic complex with respect of head size:**

*Comment: small-sized tympanoperiotic complex is observed in* ‘Balaenoptera’ cortesii *var.* portisi *and* Incakujira anillodefuego*.*

(0) Large;

(1) Small.

**242) Outer lip and dorsal border of involucrum:**

(0) Descending parallel toward anterior end;

(1) Posteriorly diverging as the outer lip is more inclined than involucrum.

**DENTARY**

**243) Cranio-mandibular joint:**

(0) Tight;

(1) Loose.

**244) Teeth on dentary at adulthood:**

(0) Present;

(1) Absent.

**245) Mental symphysis:**

(0) Present;

(1) Absent.

**246) Groove for mental ligament:**

(0) Absent;

(1) Present.

**247) Anterior torsion:**

(0) Absent;

(1) Present.

**248) Massive elongation of dentary ramus:**

(0) Absent;

(1) Present.

**249) Coronoid process height:**

*Comment: state 0 is present in archaeocetes and early mysticetes including Eomysticetidae; state 1 is observed in basal thalassotherian taxa and early-diverging Balaenopteridae; state 2 is observed in Cetotheriidae and Balaenopteridae; state 3 is observed in Neobalaenidae, Balaenidae and* Megapteranovaeangliae*.*

(0) High;

(1) Moderately high;

(2) Low;

(3) Very low-to-absent.

**250) Postcoronoid crest:**

(0) Absent;

(1) Present.

**251) Postcoronoid fossa:**

(0) Absent;

(1) Present.

**252) Size of postcoronoid fossa:**

Comment: a small postcoronoid fossa is observed only in living *Balaenoptera* species.

(0) Wide;

(1) Small.

**253) Satellite process:**

(0) Absent;

(1) Present.

**254) Size of satellite process:**

(0) Large;

(1) Small.

**255) Orientation of articular surface of mandibular condyle:**

(0) Posterodorsal;

(1) Dorsal;

(2) Posterior.

**256) Posterodorsal corner of dentary:**

(0) Round;

(1) Sharp.

**257) Angular process:**

*Comment: state 0 is observed in archaeocetes and early mysticetes including Eomysticetidae; state 1 is observed in basal thalassotherian taxa; state 2 is observed in Balaenidae, Neobalaenidae and basal balaenopterids; state 3 is present in living balaenopterids.*

(0) High;

(1) Moderately high;

(2) low;

(3) Very low.

**258) Angular process in lateral view:**

(0) Located more anteriorly than articular surface of condyle;

(1) Rounded and not protruded.

(2) Projecting ventrally;

(3) Projecting posteriorly.

(4) Squared and not protruding.

**259) Mandibular foramen:**

*Comment: a small mandibular foramen is observed in Balaenidae, Neobalaenidae, Balaenopteridae and Eschricthiidae.*

(0) Wide;

(1) Small.

**260) Shape of mandibular foramen:**

(0) Posteriorly concave;

(1) Triangular;

(2) Fissurated.

**261) Gingival foramina:**

(0) Absent;

(1) Present.

**262) Mental foramina:**

(0) Only one per dentary;

(1) Several mental foramina present per dentary.

**263) Dentary curvature in dorsal view:**

(0) Dentary with lateral concavity in dorsal view;

(1) Dentary straight;

(2) Dentary moderately bowed;

(3) Dentary strongly bowed.

**264) External curvature in dorsal view:**

(0) Absent;

(1) Continuous;

(2) Discontinuous.

**265) Presence of dorsoventral curvature in dentary in lateral view:**

(0) Absent;

(1) Present.

**266) Types of dorsoventral curvature in dentary in lateral view:**

(0) Absent;

(1) Continuous;

(2) Discontinuous.

**267) Mylohyoidal groove:**

(0) Absent;

(1) Present.

**268) Crest along the ventral border of the dentary with a parallel groove:**

(0) Absent;

(1) Present.

**269) Medial face of dentary ramus:**

(0) Flat;

(1) Convex.

(2) Concave.

**VERTEBRAE**

**270) Cervical vertebrae:**

(0) Free;

(1) Fused.

**271) Cervical vertebrae:**

(0) Elongated;

(1) Shortened.

**272) Neural processes of cervical vertebrae:**

(0) Free;

(1) Fused.

**273) Dorsal process of C3:**

(0) Present;

(1) Absent.

**274) Dorsal process of C4:**

(0) Present;

(1) Absent.

**275) Dorsal process of C5:**

(0) Present;

(1) Absent.

**276) Dorsal process of C6:**

(0) Present;

(1) Absent.

**277) Dorsal process of C7:**

(0) Present;

(1) Absent.

**278) Ventral process of C3:**

(0) Present;

(1) Absent.

**279) Ventral process of C4:**

(0) Present;

(1) Absent.

**280) Ventral process of C5:**

(0) Present;

(1) Absent.

**281) Ventral process of C6:**

(0) Present;

(1) Absent.

**282) Ventral process of C7:**

(0) Present;

(1) Absent;

(2) Reduced to a tubercle.

**283) Foramen transversarium in C3:**

(0) Complete;

(1) Incomplete.

**284) Foramen transversarium in C4:**

(0) Complete;

(1) Incomplete.

**285) Foramen transversarium in C5:**

(0) Complete;

(1) Incomplete.

**286) Foramen transversarium in C6:**

(0) Complete;

(1) Incomplete.

**287) Foramen transversarium in C7:**

(0) Complete;

(1) Incomplete.

**288) Foramen transversarium**

(0) Complete in C2;

(1) Incomplete in C2.

**289) Fusion of sacral vertebrae:**

(0) Present at least in part;

(1) Absent.

**290) Number of sacral vertebrae:**

(0) >1;

(1) 1.

**291) Sharp lateroventral projection of transverse process:**

(0) Present;

(1) Absent.

**292) Foramen at emergence of transverse process:**

(0) In caudal vertebrae;

(1) In last lumbar and caudal vertebrae.

**SCAPULA**

**293) General proportions of scapula:**

*Comment: state 0 is observed in archaeocetes and Balaenidae; state 1 is observed in all the other chaeomysticetes.*

(0) High and short;

(1) Low and wide.

**294) Orientation of scapular spine:**

(0) Divergent from margo cranialis and directed dorsally;

(1) Parallel to margo cranialis and directed anterodorsally.

**295) Development of teres fossa:**

(0) Small;

(1) Enlarged.

**296) Margo cranialis:**

(0) Straight;

(1) Convex;

(2) Concave.

**297) Inclination of margo cranialis with respect to horizontal axis:**

(0) High;

(1) Scarce.

**298) Margo caudalis:**

(0) Straight-to-scarcely concave;

(1) Highly concave.

**299) Development of supraspinous fossa:**

(0) Wide;

(1) Reduced;

(2) Invisible in lateral view.

**300) Scapular spine:**

(0) Well developed:

(1) Reduced.

**HUMERUS**

*Comment: anatomical terminology from Benke (1993).*

**301) Orientation of caput humeri:**

(0) Along longitudinal axis of humerus;

(1) Located posteriorly to longitudinal axis.

**302) Size of tuberculum majus:**

*Comment: size is assessed with respect to total humeral length: state 0 is if dorsoventral height of tuberculum majus is less than 10% of the total humeral length; state 1 is if the height is more than 15%..*

(0) Small;

(1) Large.

**303) Direction of tuberculum majus:**

(0) Anteroposterior;

(1) Dorsal;

(2) Ventral.

**304) Shape or margo ulnaris:**

(0) Straight;

(1) Concave.

**305) Shape of caput humeri:**

(0) Flat;

(1) Highly convex.

**306) Lateral edge of caput humeri:**

(0) Straight;

(1) Forming a corner.

**307) Orientation of lateral edge of caput humeri:**

(0) Anteroposterior;

(1) Oblique (from a posterodistal to an anteroproximal position);

(2) Anteroposterior posterodistally and dorsoventral anteroproximally.

**308) Lateral expansion of articular surface of caput humeri:**

*Comment: state 1 is observed in Balaenidae.*

(0) Scarce;

(1) Well developed.

**309) Deltopectoral crest:**

(0) Present;

(1) Absent.

**310) Tuberculum deltoideus:**

*Comment: state 0 is observed in those taxa where the tuberculum forms a long and evident crest; state 1 is observed in those taxa where the tuberculum is reduced to a small-sized relief.*

(0) Highly relieved;

(1) Reduced;

(2) Absent.

**311) Articulation with radius and ulna:**

(0) Rotational;

(1) Non-rotational.

**312) Position of ulnar epycondyle:**

*Comment: state 1 is observed in those taxa where the ulnar epycondyle is located close to the posterodistal corner of the ulna.*

(0) High;

(1) Low;

(2) Almost absent.

**313) Relative length of humerus:**

(0) Longer than radius and ulna;

(1) Humerus length nearly equals that of radius and ulna;

(2) Much shorter than radius and ulna.

**314) Proximal surface of tuberculum deltoideus:**

(0) Continuous with deltopectoral crest;

(1) Concave;

(2) Straight and projecting posteriorly.

**RADIUS**

**315) Proximal curvature:**

(0) Massive;

(1) Reduced-to-absent.

**316) Distal expansion:**

(0) Absent;

(1) Present.

**317) Proximal contact with ulna:**

(0) Present;

(1) Absent.

**318) Size of radius with respect to ulna:**

(0) Anteroposterior diameter similar to that of ulna;

(1) Anteroposterior diameter larger than that of ulna.

**ULNA**

**319) Olecranon: proximal corner:**

(0) Directed proximally;

(1) Directed distally.

**320) Olecranon: size:**

(0) Well developed;

(1) Reduced.

**321) Olecranon: dorsal and ventral borders:**

(0) Parallel;

(1) Diverging posteriorly;

(2) Forming a right angle.

**322) Olecranon: ventral angle:**

(0) Right angle-to-obtuse;

(1) Acute.

**323) Olecranon: posterior border:**

(0) Squared;

(1) Round;

(2) Straight.

**324) Proximal articular facet of ulna and upper side of olecranon:**

(0) Forming a corner;

(1) Straight.

**325) Distal expansion of ulna:**

(0) Absent;

(1) Present.

**MANUS**

**326) Articulation of carpals:**

(0) Tight articulation;

(1) Loose articulation.

**327) Digit number:**

(0) Five;

(1) Four.

**328) Hyperphalangy:**

(0) Absent;

(1) Present.

**329) Proportions of manus:**

(0) Manus wide;

(1) Manus narrow.

**330) Trapezium:**

(0) Present;

(1) Absent.

**331) Separate cartilagineous fields for trapezoid and unciform:**

(0) Yes;

(1) No.

**HINDLIMB**

**332) Pelvis articulated with vertebral column:**

(0) Yes;

(1) No.

**333) Massive reduction of pelvis size:**

(0) No;

(1) Yes.

**334) Functional hindlimbs in adults:**

(0) Yes;

(1) No.

**STERNUM AND RIBS**

**335) Number or ribs articulated to sternum:**

(0) >1;

(1) 1.

**336) First rib shape:**

(0) Not expanded;

(1) Expanded.

**337) Sternum formed by several sternebra:**

(0) Yes;

(1) No, only by one manubrium.

**338) Head of first rib:**

(0) Bifid;

(1) Single.

**339) Ribs with bifid head posterior to 5th:**

(0) Yes;

(1) No.

**340) Pachyosteoschlerotic ribs:**

(0) Absent;

(1) Present.

**DENTITION**

**341) Positions of upper premolars and molars:**

(0) Close to each other;

(1) Well separated by diastemata.

**342) Positions of lower premolars and molars:**

(0) Close to each other;

(1) Well separated by diastemata.

**343) Number of denticles on posterior upper teeth:**

(0) >3 along anterior or posterior borders;

(1) 3 or less along anterior or posterior borders.

**344) Dental generations:**

(0) Polyophiodonty;

(1) Monophiodonty.

**345) Heterodont teeth on dentary:**

(0) Present;

(1) Absent.

**346) Dentition reduced to a few anterior upper teeth:**

(0) No, complete dentition is present;

(1) Yes.

**347) Inferred or observed loss of mineralization in teeth (due to C4*orf* gene mutation):**

(0) Absent;

(1) Present.

**BALEEN**

**348) Inferred or observed presence of baleen:**

(0) Negative;

(1) Positive.

**349) Inferred or observed length of baleen:**

*Comment: long baleen are observed or inferred in Balaenidae and Neobalaenidae.*

(0) Short;

(1) Long.

**350) Direction of baleen racks:**

(0) Limited to posterior part of rostrum;

(1) Parallel;

(2) Anteriorly convergent.

**ADDITIONAL CHARACTERS**

**351) Rostral proportions among straight-rostrum chaeomysticetes:**

(0) narrow skull (total skull length/width of maxillae at bases of lateral processes between 3.5 and 3.9);

(1) wide skull (value between 2 and 3.4);

(2) very narrow skull (value > 4);

(3) very wide skull (value < 1.99).

**352) Distinctive anterolateral corner in supraoccipital in posterior view:**

(0) present;

(1) absent.

**353) Wide curve at posterior apex of nuchal (lambdoid crest) in posterior view:**

(0) present;

(1) absent.

**354) Direction of zygomatic process of squamosal in posterior view:**

(0) lateral;

(1) ventrolateral;

(2) dorsolateral.

**355) Triangular protrusion of inner posterior prominence of tympanic bulla:**

(0) absent;

(1) present.

**Table S1**

**Matrix for phylogenetic analysis**

Protocetidae

000-00000 0000000--0 0--------- -0-00-00-0 00-0000000 0000000000 0000000000 0000000-00 0000000000 0000000000 00000-0000 00000----0 -000000000 0000000-00 ----000--0 0000000100 000-0000-0 00000---00 00-------0 --0--00??? ???????0?0 000000000- 0?00000000 0000--0000 0000000000 00-0-00000 0000000000 0000000000 0000000000 0000000000 0????????? ?0?0?00000 0000000000 0000000000 000000000- --0000

*Cynthiacetus peruvianus*

000-00000 0000000--0 0--------- -0-00-00-0 00-1000000 0000000000 0000002000 0000000-00 0000000000 0000000000 00000-0010 00000----0 -000000000 0000100-00 ----000--0 1000000100 0000000000 00000---00 010????--0 --0--0???? ???????0?0 0001000010 0?00000000 0000--0001 0000000000 00-0-00000 0010000000 0000000000 0000000001 1000011000 0000000000 0000000000 0000000000 0011000000 000000000- --0000

*Basilosaurus cetoides*

000-00000 0000000--0 0--------- -0-00-00-0 00-1000000 0000000000 0000000000 0000000-00 0000000000 0000000000 00000-0010 00000----0 -000000100 0000000-00 ----000--0 0000000100 0000000000 00000---00 010000---0 --0--00000 00000000?0 0001000010 0000000000 0000--0001 0000000000 00-0-00000 0010000000 0000000000 0000000001 1000011010 0000000000 0000000100 0000000000 0011000000 000000000- --0000

*Dorudon atrox*

000-00000 0000000--0 0--------- -0-00-00-0 00-1000010 0000000000 0000000000 0000000-00 0000000000 0000000000 00000-0010 00000----0 -000110100 0000000-00 ----000--0 0000000100 0000000000 00000---00 010000---0 --0--00000 00000000?0 0001000010 0000000000 0000--0001 0000000000 00-0-00000 0010000000 0000000000 0000000001 1000010010 0000000000 0000000000 0101000000 0011000000 000000000- --0000

*Zygorhiza kochii*

000-00000 0000000--0 10000-00?0 00-00-00-0 00-1000000 0000000000 0000001000 0000000-00 0000000000 0000000000 00000-0010 00000----0 -000110100 0000000-00 ----000--0 1000000100 0000000000 00000---00 010000---0 --0--00000 00000000?0 0001000010 0000000000 0000--0001 0000000000 00-0-00000 0010000000 0000000000 0000000001 10000?2010 00??0????0 0000000100 0000000000 0011000000 000000000- --0000

Mammalodontidae

010-10100 1000011000 10000-0?00 0100111000 00-3100000 0000010000 0000002001 0100--0-00 1000000010 0?20000?00 00000-0000 00000----0 -0?0111110 1010000-11 ----100--0 1000000100 ?011??00?0 ?000????01 ?10000---1 000--00100 000?0?10?0 00010?000- 0000000000 0000--000? 0000000000 00-0-00100 0011000000 0000?????? ?????????? ?????????? ?????????? ?????????? ?????????? ???????0?? ?00100000- --0000

*Fucaia*

010-10001 1010111001 10000-0?01 0100101000 0102000120 0000010000 0000002000 0101000-00 1000000010 0020000000 01000-0000 00000----1 00?0111110 1010000-11 ----10110? 1000000100 ?011000010 ?000101000 3110122001 000--010-0 000?0?00?0 00010?0010 0000000000 0000--0001 0011011010 00-0-00100 0011000000 0000000000 01000011?? 1?0?1000?0 0????????? ?????????? ?????????? ??????1??? ?01000000- --0000

*Aetiocetus weltoni*

010-10001 1010111001 10000-0?01 0100111000 10-2001120 0000000000 0000002002 0100--0-00 1000000010 0000000000 02000-0000 00000----1 0000111110 101000??11 ----100--? 1000000111 1011000010 1000101?0? ?????????? ?????????? ?????????? ?????????? ??00000000 0000--0001 0001011010 00-0-00100 0011000000 ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?111110010 0-0000

*Yamatocetus canaliculatus*

110-11101 1110211001 10000-0?01 1110110000 0101000120 0000020000 0000001001 0000--0-00 1000000010 0111000000 02001-0000 00000----1 0??0111110 1010001012 ----100--? 1000010111 ?110020000 0000????0? ?????????? ?????????? ?????????? ?????????? ??00000000 0000--0000 0001111010 00-0-00100 0111000000 0000000000 000000001? ???1011100 0000000000 0100000100 011100???? ????????00 0------010 000000

*Eomysticetus whitmorei*

110-1?101 11102110?1 0------?-- -??0??0001 0??1000120 0000010000 0000000000 0000--0-00 1000000010 0011000000 02001-0000 00000----1 0000111110 1010001012 ----100--? ?100010111 111????000 00000---01 311210---0 --0--01001 001?0?00?0 00010?000- 0100000000 0000--0000 0001111010 00-0-00100 0111000000 000?000000 000?????1? ?0?1????1? ?00-000000 0100010100 000100???? ?????????? ?------010 0????0

*Micromysticetus*

?10-????? ?????????? ?????????? ?????????? ?????????? ?00??????? ???000?0?? ??0?--0-00 1?00000010 0011000000 02001-0000 00000----1 0000111110 1010001012 ----100--? ?100010111 11100??000 0000100001 311210---0 --0--01010 001?0?00?0 00010?000- 01???????? ?????????? ?????????? ?????????? ?????????? 000??????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???????0?? ??00?0

*Waharowa ruwhenua*

110-11000 1110211001 ?????????? ???0?????0 0??2000120 0000021000 0000001000 0000--0-00 1000000010 0011000000 02001-0000 00000----1 0??0111110 1010001012 ----100--? ?1000??011 111102?000 0000100001 311210---1 000--00010 00100000?0 0001000010 0100000000 0000--0000 0001111010 00-0-00100 0111000000 000?0????0 ?????????? ?0?0110011 1???0????0 0110010100 011100???? ?????1?000 0------010 ?????0

*Sitsqwayk cornishorum*

110-1?000 1110211001 0------?-- -1100-0000 0111?0?120 0000020021 1010000001 0100--0-00 1000000010 1?10000000 0101000011 00000----1 0??0001110 1010001002 ----100--? 0110110111 111002?10? 0000????0? ?????????? ?????????? ?????????? ?????????? ??00000010 0000--000? ?0?1111010 00-0-00100 0111000000 0000000000 0011?1111? ?0?1011100 010-011210 0100010100 011000???? ?????0?000 0------010 ?0???0

*Horopeta umarere*

?10-????1 111??????? ?????????? ?????????? ?????0?120 000?0????? 0??000100? ??00--0-00 1?00000010 ??????0000 0?0???0??? 00000----? ???000?11? 1010000-01 ----100--? ??????0111 11100????? ?000100001 311110---1 000--00010 01200?11?0 00010?0010 0100000000 0000--0000 001111???0 1100-????? ?111000000 0000000000 001????10? ???0100011 0????????? ?????????1 ?01000???? ?????0?000 0------010 ?????0

*Morenocetus parvus*

????????1 ?????????? 10000-1?11 0????????? ???????0?0 1111000020 1111011100 030???0-00 101-13-011 3211000000 0?11000100 21210----1 0000001131 0001000002 ----000--? ?111100111 111011?101 0120112101 ?110?0---0 --0--00??? ????00??0? ??001?0010 0????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?--?-???11 ?-1110

*Caperea marginata*

001011011 1110111011 10000-1111 0100111001 10-3212020 1121000020 1111011101 0300--0010 101-13-011 3201000000 0011000100 21210----1 0000001131 0001011012 ----300--1 0111010111 1111--0101 0120112101 111011---0 --0--001-0 01210?101? 0100100010 0011110001 1101001111 1001111013 00-0-10211 0111011100 1111111101 1111111111 1111111111 1110111211 1112110101 0010101111 0111111110 1---11-011 1-1110

*Miocaperea pulchra*

001011011 1110111011 10000-1?11 0100111001 1103212020 1121000020 1111011100 0300--0010 101-13-011 3221000000 0011000100 21210----1 0200001131 0001011012 ----200--? 0111000111 1111--0101 0120112101 1110??---0 --0--001-0 ?????????? ??001?0010 0????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?-?-1?-011 1-1110

*Balaenella brachyrhynus*

101011011 1100111201 10000-1?11 0100111001 1??3???0?0 1110100020 1111011101 0301100010 101-13-111 3111000100 0301011100 21210----1 1100001131 0021011002 ----300--? 0111100111 1111--1101 0020112101 1110?0---0 --11101??? ?????0???? ??001?0010 ???1110001 110100111? ?011?????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?-?-1?-011 1-1110

*Balaena mysticetus*

101011011 1100111201 10000-1111 0100111001 1113212020 1110100020 1111011101 0301100010 101-13-111 3111000100 0301011100 21210----1 1100001131 0021011002 ----300--1 0111100111 1111--1101 0020112101 111010---0 --11101000 012000000? 0100100010 0011110001 1101001111 1011111113 00-0-10211 011311?100 1110000000 1111111111 1110000000 0110110111 1121111000 1000011010 0111111110 0---11-011 1-1110

*Balaenula astensis*

10111??11 1100?11211 10000-1?11 0100111001 11?3001020 1110110021 1101011101 0301010110 111-13-011 3111000000 0011011100 21210----1 1100001131 0001011001 ----200--? 0111100110 1110131101 0020112101 111010---0 --10001000 012?00?00? 01001?0010 0011110001 110100111? ?011111113 00-0-10211 0111112100 ?????000?? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-011 1-1110

*Eubalaena*

101111011 1100111211 10000-1111 0100111001 1113001020 1110110021 1101011101 0301010110 111-13-011 3111000100 0301011100 21210----1 1100001131 0001011001 ----200--1 0111100111 1110131101 0020112101 111010---0 --10001000 212000001? 0100100010 0011110001 1101001111 1011111113 00-0-10211 0113112100 1110000010 1111111111 1110000000 0110110111 1121111110 1000011010 0111111110 0---11-011 1-1110

*Atlanticetus patulus*

110-11111 1110111101 11000-0?01 1100111001 10-3101030 1111110000 1111101001 0200--0-11 1001000010 1011000100 0301000010 11100----1 0110001121 1011000-02 ----100--1 0111110111 1110130100 1010112100 311011---1 000--01010 012?0?00?0 10010?0010 0011110110 0111100001 001??????? ?????????? ?????????? 0100?0??0? 0??1?????1 11???????? ?????????? ?????????? ?????????? ?????????? ?---11-110 210001

*Atlanticetus lavei*

??0-1???? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????0 ?????????? ?????????0 ????0----1 01???????? ?????????? ?????????? ?????????? ???????100 ??10112100 311011---1 010--01010 012?0?00?0 10010?0010 0011110110 0111100001 0?1??????? ?????????? ?????????? 010??????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????1

*Pelocetus calvertensis*

110-11111 1110211101 11000-0?01 1100101001 10-3?01031 1110121000 1111101001 0200--0-11 1001000010 1011000100 0301000010 11100----1 0110001121 1011000-03 ----100--1 0111110111 1110130100 1120112100 310??????? ??0--01??? ?????????? ?0010??010 ??21110110 0111100001 0011111012 1100-00120 ?113100001 010?0?00?0 ?02?1??101 11?1011110 0110011211 212?-????? ?????010?? ?????11110 0---11-110 210000

*Uranocetus gramensis*

110-11111 1110211101 11000-0?01 1100101001 10-3101131 1111110000 1111101001 0200--0-11 1001000010 1011000100 0301000110 11100----1 0110001121 1011000-14 0010100--1 0111110111 11101?0100 1020112100 311??1---1 000--01010 012?0?00?0 10010?0010 0?21110110 0111100001 00111???12 1100-00120 1113000001 100000000? ?100????01 1??0102011 0110011211 ?122?10100 011100???? ?????????? ?---11-110 23?000

*Isanacetus laticephalus*

110-11111 1110211001 11000-2?01 1100111011 10-3101021 1111121000 1111101001 0200--0-11 1001???010 1011000100 1301000110 11100----1 0110001121 10110????? ????100--1 01111?01?? ?1110-0100 1010112100 311011---1 000--01010 012?0?00?0 10010?0010 0111110110 0111100001 00111???1? ?????????? ?????????? ?????????? ?????????1 1????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 230000

*Joumocetus shimizui*

110-11111 1110011001 11000-0?01 1100111011 10-3101131 11111220?0 1111101001 0200--0-11 1001001010 10??????00 ??01??0000 11100----1 0110001121 101100???4 0010100--1 01111?0111 11110-0100 1010112100 ?1???1---? 000--0???? ?????????? ?0010????? ??11110110 0110--0001 ?01111101? ?????0013? ?112000001 ?????????? ?????????1 1????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 231110

*Parietobalaena palmeri*

110-11111 1110??1001 11000-2101 11001?10?1 10-3101021 1111112000 1111101001 0200--0-11 1001000010 1011000000 1101000100 11100----1 0110011121 1010000-14 0010100--1 0111110111 1110130100 1010112100 310001---1 000--01010 01211111?0 1001000010 1111110110 0110--0001 0011111012 1100-00120 1111000001 0100000000 0??1?????1 11???????? ?????????? ?????????? ?????????? ?????????? ?---11-110 201020

*Parietobalaena campiniana*

110-11111 1110111001 ?????????? ?100111001 10-??????? 1111122020 111??????1 02???-?-?? ?0?????010 1011000000 1101000100 11100----1 0110001121 ?????????? ?????????1 ?111100111 111??30100 1010112100 ?10001---1 000--01010 012?1?11?0 10010?0010 1111110110 0110--0001 0011111012 1100-00120 1111000001 0100000000 112??111?1 1????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 2???20

*Tiucetus rosae*

110-11??1 111??????1 110?0-0?02 2100??10?1 1??3000121 111????-?? 1?11101001 0200--0-11 1001111010 1011000000 0101000100 11101000?1 0110011121 1011101014 0010100--1 0111100111 1110100100 1110112100 ?11???---1 000--01??0 ?????????? ?0010??010 ??11110110 011???0001 001??????? ?????????? ?????????? ?????????? ?????????1 1????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 2?1110

*Taikicetus inouei*

????1???1 111???10?1 10000-0?01 0100??1001 ?????0?020 1111122100 1110100001 0200--0-00 0001011000 1021000002 1101011020 11100----1 01?0011121 1012100-03 ---0000--? ??11110??? 1110--?1?0 1120112100 010??20001 110--10??? ?????????? ????0?0??? ??2???010? ???110010? ???111??12 1100-00120 111????000 010??????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?---11??10 ??0000

SMNH-VeF-62

110-11?1? 1110211011 11000-???1 2100111011 10?????0?? 1111010021 ?111001001 0200--0-00 1001010000 1011000000 1301001000 11100----1 01?0001121 1012101004 0010100--? ??1110011? ?11????1?0 ?110112100 ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ??111??112 1100-00120 1111000001 ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 2??110

*Parietobalaena yamaokai*

110-11011 1110111??1 11000-0?01 21001?10?1 10-????0?? 1111020001 ?11110100? 0200--0-00 1001000000 10220?0000 1101001000 11100----1 0000001121 1010100-14 0010100--? ??1111011? ?11???0100 ?????????? ?????????? ?????????? ?????????? ?????????? ??11110100 01?0--0011 00?1111012 1100-00120 1112100001 010?00??00 ???11????1 ??01000112 1????????? ?????????? ?????????? ?????????? ?---11-110 2?1020

*Diorocetus shobarensis*

110-11111 1111211001 11100-0?01 21001?1001 10-3101020 11110020?? ????10000? ?201--0-00 10010000?0 1000000?00 ?301001000 11100----1 0??0001121 1012101-14 0010100--? ??1100011? ?1????0100 ?????????? ?????????? ?????????? ?????????? ?????????? ??1?11010? ???1100011 00?1111012 1100-????0 1113100001 ?????????? ?????????1 1001000112 1????????? ?????????? ?????????? ?????1110? 0---11-110 23002?

*Diorocetus chichibuensis*

110-11111 1111111101 11000-0?01 1100111001 10-2000020 1111010000 ?111000001 0200--0-00 1001000000 1011000??0 0101001120 11100----1 00?0001121 1012101014 0011000--? ????11011? ???0110100 1????????? ?????????? ?????????? ?????????? ?????????? ??11110100 0111010011 0011111?12 1100-????0 111????001 ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 2?1000

*Diorocetus hiatus*

110-11111 1110110110 11000-0?01 2100111001 10-2001030 1111020000 1111100001 0200--0-00 1002000010 1011000100 0101001100 11100----1 0010001121 1012100014 0011000--1 0111110111 1110130100 0010102000 311013---1 000--01010 212?1?11?0 10010?0010 1111110100 0110--0011 0011111012 1100-00131 ?111000001 01?????0?? ??2????101 1101012010 0????????? ?????????? ?????????? ?????????? ?---11-110 201000

USNM187416

110-11?11 1110110110 10000-0?02 2100111001 10-2001020 1111010021 1111101001 0200--0-00 1002000010 1021000100 0101001100 11100----1 00?0001121 1012100-14 0001000--1 0111110111 1110130100 0120112000 ?????????? ?????????? ?????????? ?????????? ??111101?? 0111010011 01???????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???-11-110 2?10??

*Mixocetus elysius*

110-11111 1110110110 1111002?01 1100100001 10-3001120 1121021002 1210102001 0210--1-00 1002111010 202100000? 0301000001 1100?----1 0010001120 0022110-01 ----000--1 0111110111 1110110100 ??22?????? ?????????? ?????????? ?????????? ?001?????? ?????????? ?????????? ?1?1111012 ???0-00211 ?11?000000 01?0000000 000???00?1 ?1?1?1?111 1????????? ?????????? ?????????? ?????????? ?---11-110 20110?

*Cetotherium rathkei*

100-1???0 111??10110 1111102?02 2???10?001 1103101130 1121021021 1210102001 0210--0-00 1002111010 2022000001 0301000000 11000----1 00?0001120 1012100-14 0111000--1 0111010111 1111--0110 0????????? ?????????? ?????????? ?????????? ?????????? ??201101?? 0111000011 01???????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?-?-11-110 2?1100

*Cetotherium riabinini*

100-11?10 1110110110 1111102?02 210011?001 10-2211120 1121010001 1210102001 0210--1-00 1002111010 2022000001 0301000000 11000----1 0110001120 1012100-14 0011000--1 0111110111 1110120100 0120????0? ?????????? ?????????? ?????????? ?????????? ??201101?? ???0--00?1 01?1111012 1100-10021 2111000001 010?0001?0 002?0001?1 1000110002 111101???1 1112-10100 011100???? ??111????1 1---11-110 221100

*Metopocetus durinasus*

??0-1???0 111??????0 111?100?02 2?????0??? ???3???130 11???????? ???010200? ?210--1-00 1002111010 ????000??? 0301000101 11?00----1 0??0??112? 1012100-14 0111000--1 ?111?10111 11101??100 ????????0? 311113---1 000--00010 012?1?11?0 10010?0010 10???????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? ??110?

*Metopocetus hunteri*

??0-1???0 111??????0 111?000?02 2????????? ???????1?0 1121?????? ???010200? ?210--1-00 1002111010 2022000001 0301001101 11?01000?1 0000001120 1012100-11 ----100--1 ?111110111 1110120100 011010201? ?1111????? ???????010 012?1?11?? ?0000?0010 1021110110 0110--0001 011??????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? ??1100

*Piscobalaena nana*

100-11110 1110110110 1111110?02 2100111001 1104001130 1121021000 1210102001 0210--1-00 1002111010 2022000101 0301000000 11000----1 0110001120 0022100-11 ----200--1 01110101?? ?111--0100 0100102000 311113---1 000--00010 012?1?1110 00010?0010 1101110110 0110--0001 0111111012 1100-00131 2112000001 0100000000 0020001101 1101011100 0111011211 2111210100 0111001??? 0?11110110 0---11-110 221120

*Herpetocetus morrowi*

100-11??0 111?110110 1111112?02 2100111001 10-3001130 1121022001 1210102001 0210--0-00 0002111010 1022000001 0001002100 11000----1 0100001120 1012100-14 0012000--1 0111110111 1110020110 1100102010 311113---1 100--01010 012?1?1110 10010?0010 1001110110 0110--0001 0111111012 1100-00130 1112000001 0????????? ????????01 110??????? ?????????? ?????????? ?????????? ?????????? ?---11-110 221100

*Herentalia nigra*

??0-1???0 111??????0 111?000?02 2????????? ???????120 1121?????? 121010200? ?210--1-00 1002111010 ?????????? ???1??0001 11?01001?1 0000?0112? 0002101011 ----200--1 ?111010111 1110220100 0120102000 ?1111????1 000--?1010 ?????????? ?00??????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? ??10??

*Thinocetus arthritus*

??0-1???? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???????-?? ?????????0 ?????????? ?????????? ?????????? ??????1??? ?????????? ?????????? ????010111 111???0100 ??20112010 31111????1 000--00100 01??1?11?0 00010?0010 1011110100 0111000011 011??????? ?????????? ?????????? 010000??00 0??0????01 1101110111 0112011211 1112210100 011100???? ?????10110 ???????1?? ?????0

*Halicetus ignotus*

??0-1???? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???????-?? ?????????0 ?????????? ?????????? ?????????? ??????1??? ?????????? ?????????? ?????????? ?????????? ??10112000 31101????0 100--01100 01??1?11?0 00010?0010 1011110100 0111010011 011??????? ?????????? ?????????? 0100000000 0110111101 110??????? ?????????? ?????????? ?????????? ?????????? ???????1?? ?????0

*Titanocetus sammarinensis*

110-11010 1110110110 11100-2?00 0100100001 10-3001100 1111120002 1100102001 0210--0-00 1001111010 1011000001 0301000011 11100----1 0??0001120 0-02100-01 ----200--1 0111010111 1110120100 01???????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?1?1111012 1100-10120 1113100000 010??????? ????????11 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? ?1012?

*Cophocetus oregonensis*

110-11111 1110110110 11010-2?01 1100100001 10-3001120 1111121002 1210102001 0210--0-00 1002111010 1022000100 0101000010 11110----1 0011001121 1-12100-04 0101000--1 0111010111 1110110100 0020?????? 311013---1 000--00100 012?0?01?0 10010?0010 0111110100 0110--0011 00111??012 1100-20120 2112100001 0100000000 011?????01 1101111002 011?011211 2122-????0 010100???? ?????????? ?---11-110 21011?

*Aglaocetus moreni*

110-11110 1110110110 10000-2?01 1100110001 10-3001100 1111110001 1110102001 0210--0-00 1002111010 1011000100 0101000010 11110----1 0011001121 1-12100-04 0101000--1 0111010111 1110110100 0020?????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???1111012 1100-0012? ?112000001 ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 21????

*Eschrichtius robustus*

101011011 1110211001 10000-2211 0100111001 10-4102120 1121110021 1220102101 0211--0-00 1002121010 2122000101 0301000001 2111111?21 0101001120 2-22101114 11103010-1 0111110111 1110100110 1020????02 3101120001 000--111-0 01211011?0 101111100- 1211111000 0111000010 0111111013 00-1110131 2112011000 0100000000 0001111101 1100110001 1112011211 1111211100 0201011111 ??11111110 0---11-110 2-1120

*Eschrichtioides gastaldii*

110-11??0 1110?????1 10000-2?11 0100??1001 10-3101120 1121110011 1220100001 0211--0-00 1002121010 2111000101 0301000101 21011000?1 01?1001120 0-02101101 ----00???1 0111100111 111???0110 ?????????? ?????????? ?????????? ?????????? ?????????? ??10111000 0111000010 0111111013 00-1110131 2112011000 010??????? ????????11 ?????????? ?112011211 2121-????0 020200???? ??111????? ?---11-110 2?112?

*Archaeschrichtius ruggieroi*

????????? ? ????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???????-?? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???1111012 11010????? ?112011002 ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-11? ??????

IRSNB M2231

110-????? 111???1001 10100-??1? ??????1?1? ???????1?0 1230020022 1320102011 131???1-11 1003121010 ????????01 0?01000000 21211011?1 0110001121 0002100-01 ----200--? ?111110111 111011?1?? 1020112100 1110020011 110--11010 012?0?00?0 11111?110- 0131111100 0101100001 0011111012 1100-21331 2113100002 010????0?? ??2????111 ???1110002 1112011211 2112-10?00 01120?1??? ?????????? ?---11-110 2?1120

*‘Balaenoptera’ ryani*

????????? ?????????? 1???0-???2 0????????? ???????0?0 1231?0???2 111110100? ?210--0-01 1002121010 ?????????? ???1??1100 21?11000?1 010?00112? 1012101004 1110100--? ?11??10111 111020?110 1????????? ?111120011 000--11010 012?0?01?0 00011?1010 01????11?0 01?110000? ??0??????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? ??11?0

*Protororqualus cuvieri*

110-11010 1110211001 10100-2?12 1100111111 10-4101120 1242101012 1320102011 0220--1-11 1003021010 1?11000??? ??01002100 2121?????1 01?1001121 1012101014 0201100--? 0111100111 111???0110 ?????????? ?????????? ?????????? ?????????? ?????????? ??3111110? ?10??000?1 01?1111012 1100-21241 ?111000000 0100????0? ????????01 11?111?112 1112001211 1121210100 0101001??1 ??1111???? ?---11-110 211120

*Protororqualus wilfriedneesi*

??0-????? 11???????? 101?0-2?12 2??0?11??? ???????1?? 12421???11 1??0102012 122???1-11 1003021010 ???1?10101 0?01001000 21211110?1 010100112? 10121????4 0201100--? ?111110111 111010?1?0 1120112100 ?111120001 100--001-1 112?0?01?? ?1110?1010 0131111100 1101100001 011??????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?112?11211 ?1???????? ?????????? ?????????? ???????1?? 2?1120

MGPT UT PU13842/5

110-11112 1111211??1 10100-1?12 1100??1111 10-4201120 1242200012 1320102012 1211--1-11 1003021010 1121010101 0101001100 2121?????1 01?1001121 1012101014 0201110--1 0111100111 111010?110 1?2??????? ?111120001 100--011-1 112?0?01?0 21110?0010 0131111100 1101100001 0111111012 1100-21241 2112100000 0100000000 0021111101 1101112112 1110010001 2122-10100 011100???? ??11111111 0---11-110 211120

*‘Balaenoptera’ cortesi* var. *portisi*

100-11112 111011???1 10100-0?12 2111??1??1 1??????130 1231100011 1321102111 122???0-11 1002121010 1011100111 0100000100 2121112230 1?00011213 1021111004 1212100--? 0111110111 1111--0110 1120112100 ?111120011 110--001-0 112?0?00?0 21110?000- 0131111110 010??0000? ?1?1111012 1100-21131 2112000000 0100000000 000?????11 ???1112112 1112011211 11122????1 001200???? ?????????? ?---11-110 221120

NMR7096

??0-1?112 1110?????? 10100-0?12 2101?????1 ???????130 1231?????? ???110201? ?221--1-11 1002121010 1211100012 0100000100 211211123? 1100001121 3012110-04 1212100--? ?111110111 11100??1?0 1020102100 11010200?1 110--00010 112?1?11?? ?1110?000- 0131111110 010110000? ?11??????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?-?-1?-110 2?1120

*Marzanoptera tersillae*

110-110?1 1110??10?1 10100-2?12 210???1111 1??4010130 1232100012 1320102011 1210--1-11 1003121010 2011000001 0301001100 2121110210 1000011212 2022101004 1210300--? ?111110111 111011?1?0 1110112100 1111120001 110--001-0 0???1?11?? ?1110?100- 01???????? ?????????? ?????????? ?????????? ?????????? 0100000000 0021111101 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? 2?112?

*Plesiobalaenoptera quarantellii*

110-11111 11112110?1 10100-2?1? 1100111?11 1????????? 12?21????? ???01????? ??1????-11 1???121??? ?????????? ?????????? ?????????? ???????12? 2022010-04 01030????? ?????1011? ?????????? ??21112000 1111020011 110--00010 012?1?11?0 21110?0011 1130111100 1101100001 0011111012 1100-21341 0113100002 01000???00 ???11????1 11???????? ?????????? ?????????? ?????????? ?????1111? ?---11-110 2???20

*Plesiobalaenoptera* sp. (SAM55001)

????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???????-?? ?????????0 ?????????? ???0?????0 ?????????1 010100???? ?????????? ?????????? ?111?????? ???????1?? ?????????? 1110200111 010--00010 012?1?11?0 21110?0011 1030111100 1101100001 0?1??????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? 2???20

*‘Plesiobalaenoptera’ hubachi*

110-11010 1110111001 10100-2?11 1100111111 1??3011120 1232101021 1320102011 1210001-11 1003121010 1021000000 0101000100 11211100?1 0100001121 2022101004 1110300--? 0111110111 11?11101?0 1021112002 1111?2000? ??0--00??? ????1?11?0 21110?0011 11???????? ?????????? ???1111012 1100-21241 ?113000002 0100000000 0021111101 1101110111 1110011211 2112110100 0111001111 0111111111 0---11-110 23112?

*Parabalaenoptera baulinensis*

110-11111 1110??1001 10100-2?11 2100111?01 1??3001120 1232201022 1320102011 ?220001-11 1003121010 1021100001 0301001100 21211?2??1 01?000?121 0022101014 1100210--? 0111??011? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???1111012 1110-21241 0113000002 0100????0? ???1????01 11???????? ?????????? ?????????? ?????????? ?????????? ?---11-110 2?1120

*Fragilicetus velponi*

??0-????? 11???????? 10100-2?11 2????????? ???????110 12322???22 1??010201? 1221--1-11 1003121010 10110?0000 0301000101 11201122?1 0100001121 2022101014 1110300--? ?111110111 111111?1?0 1120112100 11111200?1 110--001-1 112?1?11?0 11110?0010 11???????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? 2?1120

*Plesiobalaenoptera hubachi*

110-11010 1110111001 10100-2?11 1100111111 1??3011120 1232101021 1320102011 1210001-11 1003121010 1021000000 0101000100 11211100?1 0100001121 2022101004 1110300--? 0111110111 11?11101?0 1021112002 1111?2000? ??0--00??? ????1?11?0 21110?0011 11???????? ?????????? ???1111012 1100-21241 ?113000002 0100000000 0021111101 1101110111 1110011211 2112110100 0111001111 0111111111 0---11-110 23112?

*Incakujira anillodefuego*

110-11111 1110311101 10100-2?11 1100111111 10-4011130 1242200112 1320102012 1210001-11 1003121010 1011110111 0201001100 21211????1 01?0001121 2022101012 ----301101 0111110111 1110210110 1121?????? ?11??20??1 100--00??? ?????????? ?1110?001? ??31111110 1101100001 0111111012 1100-2134? ?112000?0? 0100000000 00?0????01 1111111110 1110011211 2122110100 0111001111 01111?1?11 0---11-110 201120

*Archaebalaenoptera eusebioi*

110-11111 1110311101 10100-2?12 1100111111 10-3011130 1242202122 1320102012 1211--1-11 1003121010 1011110112 0101000100 21211100?1 0010001121 2022101012 ----30110? 0111110111 11102001?0 102??????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?1???????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---1?-110 20112?

*Archaebalaenoptera castriarquati*

110-1?110 1110111101 10100-2?12 1100111111 ???3000120 1242100022 1320102011 1221101-01 1013121010 11110?0102 0301001100 1121?????? ???000?121 3022101014 121001100? 01111101?? ?????????? ?1???????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???1111012 1100-212?? ?111?????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 2?112?

MHNL M1610

110-1?012 1110111101 10100-2?12 2100111111 ???4010120 1242100021 1320102012 ?221--1-11 1003121010 1011010102 0101001100 2121?????? ???000?121 3022101014 1210011001 0111?101?? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???1????1? ?????????? ?111?????? 01000000?? ????????01 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 23112?

*Archaebalaenoptera liesselensis*

??0-????? ?????????? 10??0-2??2 2????????? ???????1?0 1242?????? ???010201? 1221--1-01 1003121010 ????????02 ???1001100 21?11003?? ??0000112? 3022101014 121001100? ?111110111 111020?1?0 1121102100 ?11??200?1 110--10010 012?0?01?? ?1110????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? 2?11??

*Nehalaennia devossi*

?10-11??0 111?111001 10100-1?12 2100111111 10-3010130 1232102121 1320102011 1310001-11 1003121010 202200000? 0101001100 21211003?? ???0001121 0022101012 ----01100? 0111110111 1111--?1?0 1110112100 ?111120001 110--001-0 ?????????? ?1110?0??? ?????????? ?????????? ?????????? ?????????? ?????????? 010??????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 2?112?

*‘Marzanoptera’ bertae*

??0-????? ?????????? 1???0-???? 2????????? ???????1?? 1231100110 1320102011 121???1-11 1003121010 2012000101 0201001100 2121100??? ???1001121 2022101004 0111300--? ?111110111 11?????1?0 1110112100 ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? 2?112?

Shimajiri-kujira

??0????01 ??????1110 1?100-???? 2???111111 ???????1?? 1232100122 1130122011 121???1-11 1003121000 2011000101 0201001100 2121?????? ???1001121 ?0?2101012 ----?00--? ?111110111 11????01?? ?1???????? ?11??20001 010--00??? ?????????? ?1110?0010 ??3101110? ???110?00? ?0???????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? 2?????

Maesawa-cho

110-11011 1110?11101 10100-??12 1100111111 10-4102130 1232200?20 1320102012 ?211--1-11 10031210?0 1211010001 0201001100 2121?????1 ????00?121 0022110-04 1010200--? ?11111011? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ???1111012 1100-212?? ?1110000?? 010??????? ?????????1 ???1?1???? ?????????? ????0????? ?????????? ?????????? ?---11-110 2?????

*Miobalaenoptera numataensis*

????????? 11????1101 ?????-???? ????????1? ?????????? 1231100120 1320102012 121????-?1 1003121010 1011110111 0101001100 2121?????1 01?0001121 00221????2 ----000--? ?111110111 111????1?0 ??201121?? ?111120001 100--001-0 012?1?11?0 11111?1010 01???????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ???????1?? ???????1?? 2?112?

*Diunatans luctoretemergo*

????????1 ?????????? 101?0-1?11 0????????? ???4012120 1232?????? ??201201?? 132???1-01 1003121010 2022000001 0101000100 2121111??1 0100001121 2002110-04 1110300--? ?111110111 111020?1?0 1120112100 ?111120011 110--001-1 011?1?11?? ?1111?0010 0131111111 110???0000 001??????? ?????????? ?????????? 01000???00 ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1?? 2?1120

*Norrisanima miocaena*

?10-?1??1 111??11001 10000-2?21 0100111111 10-3011120 1232110022 1320102012 1311--1-11 1003131010 1211010001 0201001100 21211????1 01?0001121 0002110-02 ----000--? 0111111111 1111--0110 1?2??????? ?111120011 1?0--001-0 012?0?00?0 21111?000- 1011111100 1110001101 1????????? ?????????? ?????????? ?????????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?-?-?1?110 2?1120

*‘Balaenoptera’ siberi*

110-11011 1110211101 10100-1?22 1100111111 1??41?2130 1232202121 1320112112 ?320011--1 111-131010 1?22010?01 0?01001000 2121?????1 0???001121 0002110-02 ----000--1 011111?111 11???????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ??11111111 00-0-212?? ?111?????? ?10??????? ?????????1 ?111110111 1110011211 1122010100 0111001111 1111111??? ?---11-110 2?112?

*Megaptera novaeangliae*

110-11011 1110211101 10100-2211 0100111111 10-4010120 1232202121 1320102012 1320011-11 1003131010 1211010101 0201001100 2121112301 0111001121 0022100-14 1010310--1 0111101111 1111--0110 1021112102 3110120011 110--101-0 012?0?00?0 11111?000- 0130111110 1101100001 0011111013 1110-21341 2113200011 0100011111 0001111101 1111112111 1112011211 1122011100 1112111111 1111111111 0---11-110 211120

*Balaenoptera physalus*

110-11011 1110111101 10100-1222 0100111111 10-4010130 1232202021 1320102012 1321--1-11 1003131010 1221011101 0201002100 2121112321 0111001121 2102100-14 1110310--1 0111101111 1110210110 1021112102 1110120111 100--011-1 0121010010 111101000- 0030111101 1101100001 0011111012 1110-21341 2113200012 0100000000 0021111101 1111112111 1110011211 1112010100 0111001111 1111111111 0---11-110 231120

*Balaenoptera acutorostrata*

110-11011 1110111101 10100-1222 0100111111 10-3202130 1232200020 1320102012 1320011-11 1003131010 1221011101 0201002100 2121112331 0111001121 0102100-14 1110311101 0111101111 1110210110 1011112102 1110120011 000--111-0 0121010000 111111000- 0130111101 1101100001 0011111012 1110-21341 2113200012 0100000000 0020101101 1111112111 1112011211 1112010100 0111001111 1111111111 0---11-110 231120

*Balaenoptera bonaerensis*

110-11011 1110111101 10100-1222 0100111111 10-3202130 1232200020 1320102012 1320011-11 1003131010 1221011101 0201002100 2121112331 0111001121 0102100-14 1110311101 0111101111 1110210110 1011112102 1110121111 000--011-0 012?0?0000 11111?000- 0130111101 1101100001 0011111012 1110-21341 2113200012 010?000000 0020101101 1111112111 1112011211 1112010100 0111001111 1111111111 0---11-110 231120

*Balaenoptera omurai*

110-11011 1110211101 10100-1222 0100111111 10-4000130 1232200020 1320102012 1320001-11 1003131010 1?21011101 0201002100 21211123?1 0111001121 2002100-14 1110311101 0111101111 1110230110 1021112102 1110121011 010--111-0 012?0?00?0 11111?000- 0030111101 1101100001 0011111012 1110-21331 2113200012 010??????? ?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 2?1120

*Balaenoptera brydei*

110-11011 1110211101 10100-1222 0100111111 10-4001120 1232200111 1320102012 1321--0-11 1003131010 1?21011101 0201002100 21211123?1 0111001121 0002101014 1110311001 0111101111 1110210110 1021112101 3110120111 000--111-0 212?0?00?0 11111?000- 0030111101 1101100001 0011111012 1100-21331 2113200012 0100000000 0021111101 1111112111 1112011211 1112010100 0111001111 1111111111 0---11-110 231120

*Balaenoptera edeni*

110-11011 1110211101 10100-1212 0100111111 10-3000130 1232200111 1310102012 1320011-11 1003131010 1221011101 0201002100 21211123?1 0111001121 2102101014 1110311101 0111101111 1110210110 1021112101 3110120111 000--111-0 212?0?0010 11111?000- 0030111111 1101100001 0011111012 1100-21331 2113200012 0100000000 0020001101 1111112111 1112011211 1112010100 0111001111 1111111111 0---11-110 231120

*Balaenoptera borealis*

110-11011 1110211101 10100-1222 0100111111 10-4000120 1232202110 1320102012 1321--1-11 1003131010 1221011101 0201102100 21211123?1 0111001121 2002100-14 1110311101 0111101111 1110210110 1021112102 1110121111 110--111-0 2121010010 111111100- 0130111101 1101100001 0011111012 1100-21301 2113200012 0100000000 0021111101 1111112111 1112011211 1122110100 0111001111 1111111111 0---11-110 201120

*Balaenoptera musculus*

110-11011 1110211101 10100-1221 0100111111 10-4001120 1232200022 1320112112 1321--1-11 101-031010 1111011101 0201001100 21211123?1 0111001121 2102111004 1110310--1 0111101111 1110210110 1021111101 1110121111 110--11010 21210100?0 111111100- 0030111101 1101100001 0011111012 1100-21301 2113200012 0100000000 0120000001 1110011010 1112011211 1122110101 0111101111 1111111111 0---11-110 221120

**Institutional Abbreviations**

AMNH, American Museum of Natural History, New York, USA;

CASG, California Academy of Sciences, Department of Geology, San Francisco, California, USA;

ChM, The Charleston Museum, Charleston, USA;

CM, Condom Museum, University of Oregon, Eugene, Oregon; USA;

GNHM, Gamagori Natural History Museum, Gamagori, Japan;

GMNH, Gunma Museum of Natural History, Gunma, Japan;

KMNH, Kitakyushu Museum of Natural History and Human History, Kitakyushu, Japan;

LACM, Natural History Museum Los Angeles County, Los Angeles, California, USA

MAB, Oertijdmuseum Boxtel, Bosscheweg 80, 5283 WB Boxtel, The Netherlands;

MAUL, Museo dell’Ambiente, Università di Lecce, Lecce, Italy;

MB, Museum f¨ur Naturkunde, Humboldt–Universitat zu Berlin;

MGGC, Museo Geopalaeontologico ‘G. Capellini’, Bologna, Italy;

MCA, Museo Geopalaeontologico ‘G. Cortesi’, Castell’Arquato, Italy;

MHNL, Museo de Historia Natural, Lima, Peru;

MLP, Museo de La Plata, La Plata, Argentina;

MNHL, Muséum national d’Histoire naturelle, Paris, France;

MPTAM, Ente Gestione Aree Protette Artigiane, Asti, Italy and Museo Paleontologico Territoriale dell'Astigiano e del Monferrato, Asti, Italy;

MRSN, Museo Regionale di Scienze Naturali, Torino, Italy;

MSM, Museum Sønderjylland, Department Natural History and Palaeontology, Gram, Denmark;

MSNT, Museo di Storia Naturale del Territorio, Calci, Italy;

MuMAB, Museo Mare Antico e Biodiversità, Salsomaggiore Terme, Italy;

NBC, Naturalis Biodiversity Center, Leiden, Holland;

NFL, Numata Fossil Museum, Hokkaido, Japan;

NHG, Natuurlijke Historie Genootschap, Koninklijk Zeeuwsch Genootschap; collection housed at and curated by the Zeeuws Museum, Middelburg, The Netherlands;

NMNH-P, Academician V.A. Topachevsky Paleontological Museum of the National Museum of Natural History of the National Academy of Sciences of Ukraine, Kiev, Ukraine;

NMB, NatuurMuseum Brabant, Tilburg, Holland;

NMR, Natuurhistorisch Museum, Rotterdam, Holland;

NMV, Museum Victoria Palaeontology Collection, Melbourne, Australia;

NSMT, National Science Museum, Tokyo, Japan;

OU, Otago University, Dunedin, New Zealand;

PIN, A.A. Borisyak Paleontological Institute, Russian Academy of Sciences, Moscow, Russia;

RBINS, Royal Belgian Institute of Natural Sciences, Brussels, Belgium;

SDNHM, San Diego Natural History Museum, San Diego, California, USA;

SKKC, Suginami Kagaku Kyoiku Center, Tokyo;

SMSN, Staatliches Museum für Naturkunde, Stuttgart, Germany;

UCMP, Museum of Paleontology, University of California, Berkeley, California, USA;

UM, University of Michigan Museum of Paleontology, Ann Arbor, Michigan, USA;

USNM, United States National Museum of Natural History, Smithsonian Institution, Washington, DC, USA;

UWBM, Burke Museum of Natural History and Culture, University ofWashington, Seattle,WA, USA;

ZMA, Instituut voor Systematiek en Populatiebiologie/Zoölogisch Museum, Amsterdam, Holland (the zoological and paleontological collections of ZMA recently moved to NBC).

**Table S3**

**Geographic occurrences and ages of the taxa used in phylogenetic and palaeobiogeographic analyses**

|  |  |  |  |
| --- | --- | --- | --- |
| **Taxon name** | **Estimated stratigraphic range** | **Areas of occurrence** | **References** |
|  |  |  |  |  |
| *Protocetus atavus* | 48.6 | 40 | Mediterranean | Paleobiology Database |
| *Georgiacetus vogtlensis* | 40.4 | 37.2 | North Atlantic | Paleobiology Database |
| *Gaviacetus razai* | 48.6 | 40.4 | Indian  | Paleobiology Database |
| *Maiacetus inuus* | 48.6 | 40.4 | Indian | Paleobiology Database |
| *Basilosaurus cetoides* | 37.2 | 33.9 | MediterraneanNorth Atlantic | Paleobiology Database |
| *Cynthiacetus peruvianus* | 37.2 | 33.9 | South Pacific | Paleobiology Database |
| *Dorudon atrox* | 37.2 | 33.9 | Mediterranean, North Atlantic | Paleobiology Database |
| *Zygorhiza kochii* | 37.2 | 33.9 | North Atlantic | Paleobiology Database |
| *Mammalodon colliveri* | 28.4 | 23.03 | South Pacific | Paleobiology Database |
| *Janjucetus hunderi* | 23.9 | 27 | South Pacific | Fitzgerald (2006) |
| *Fucaia buelli* | 33.9 | 31 | North Pacific | Marx *et al.* (2015) |
| *Aetiocetus weltoni* | 28.4 | 23.3 | North Pacific | Paleobiology Database |
| *Waharoa ruwhenua* | 27.3 | 20.43 | South Pacific | Boessenecker & Fordyce (2015) |
| *Yamatocetus canaliculatus* | 28.4 | 23.3 | North Pacific | Paleobiology Database |
| *Eomysticetus whitmorei* | 28.4 | 23.3 | North Atlantic | Paleobiology Database |
| *Micromysticetus rothauseni* | 33.9 | 28.4 | North Atlantic | Paleobiology Database |
| *Horopeta umarere* | 27.3 | 25.2 | South Pacific | Tsai & Fordyce (2015) |
| *Sitsqwayk cornishorum* | 28.4 | 23.03 | North Pacific | Peredo & Uhen (2016) |
| *Morenocetus parvus* | 20.03 | 15.97 | South Atlantic | Buono *et al.* (2018) |
| *Miocaperea pulchra* | 11.608 | 7.246 | South Pacific | Bisconti (2012) |
| *Caperea marginata* | 0.012 | 0.0 | South Pacific | Paleobiology Database |
| *Balaenella brachyrhynus* | 5.3 | 5.0 | North Sea | Bisconti (2005) |
| *Balaena mysticetus* | 0.012 | 0.0 | North Atlantic, North Pacific | Paleobiology Database |
| *Eubalaena glacialis* | 0.012 | 0.0 | North Atlantic | Paleobiology Database |
| *Balaenula astensis* | 3.4 | 3.2 | Mediterranean | Bisconti (2000) |
| *Titanocetus sammarinensis* | 15.97 | 13.81 | Mediterranean | Bisconti (2006) |
| *Tiucetus rosae* | 13.65 | 7.246 | South Pacific | Paleobiology Database |
| *Metopocetus hunteri* | 11.608 | 7.246 | North Sea | Paleobiology Database |
| *Cophocetus oregonensis* | 20.43 | 15.97 | North Pacific | Paleobiology Database |
| *Aglaocetus moreni* | 20.43 | 15.97 | South Atlantic | Paleobiology Database |
| *Mixocetus elysius* | 11.608 | 7.246 | North Pacific | Paleobiology Database |
| *Uranocetus gramensis* | 11.608 | 7.246 | North Sea | Paleobiology Database |
| *Isanacetus laticephalus* | 20.43 | 15.97 | North Pacific | Kimura and Ozawa (2002) |
| *Metopocetus durinasus* | 15.97 | 13.65 | North Atlantic | Paleobiology Database |
| *Diorocetus hiatus* | 15.97 | 13.65 | North Atlantic | Paleobiology Database |
| *Atlanticetus patulus* | 15.97 | 13.65 | North Atlantic | Paleobiology Database |
|  |  |  |  |  |
|  |  |  |  |  |
| *Parietobalaena palmeri* | 15.97 | 13.65 | North Atlantic | Paleobiology Database |
|  |  |  |  |  |
| *Pelocetus calvertensis* | 15.97 | 13.65 | North Atlantic | Paleobiology Database |
| *Joumocetus shimizui* | 11.608 | 7.246 | North Pacific | Kimura and Hasegawa (2010) |
| *Parietobalaena campiniana* | 15.0 | 13.2 | North Sea | Bisconti *et al*. (2013) |
| USNM 187416 | 17.0 | 15.0 | North Atlantic | Gottfried *et al.* (1994) |
| *Piscobalaena nana* | 11.608 | 4.0 | South Pacific | Paleobiology Database |
| *Herpetocetus morrowi* | 3.6 | 2.6 | North Pacific | Paleobiology Database |
| *Cetotherium riabinini* | 11.6 | 7.246 | Paratethys | Paleobiology Database |
| *Cetotherium rathkei* | 13.65 | 7.246 | Mediterranean (Paratethys) | Paleobiology Database |
| *Thinocetus arthritus* | 13.65 | 11.608 | North Atlantic | Paleobiology Database |
| *Halicetus ignotus* | 13.65 | 11.608 | North Atlantic | Paleobiology Database |
| *Herentalia nigra* | 11.608 | 7.246 | North Sea | Paleobiology Database |
| *Archaeschrichtius ruggieroi* | 11.0 | 7.5 | Mediterranean | Bisconti & Varola (2006) |
| *Eschrichtioides gastaldii* | 5.0 | 3.0 | Mediterranean | Bisconti (2008) |
| *Eschrichtius robustus* | 0.1 | 0.0 | North Sea, North Atlantic, North Pacific | Paleobiology Database |
| *‘Balaenoptera’ ryani* | 11.608 | 7.246 | North Pacific | Paleobiology Database |
| RBINS M. 2231 | 5.0 | 5.0 | North Sea | Bisconti & Bosselaers in prep. a |
| *Marzanoptera tersillae* | 3.6 | 3.2 | Mediterranean | Bisconti *et al*. (2020a) |
| *Archaebalaenoptera castriarquati* | 3.8 | 2.558 | Mediterranean | Bisconti (2007a) |
| *Protororqualus cuvieri* | 3.1 | 3.0 | Mediterranean | Bisconti (2007b) |
| *‘Balaenoptera’ cortesii* var. *portisi* | 3.6 | 2.588 | Mediterranean, North Atlantic, North Pacific | Deméré *et al.* (2005) |
| *‘Plesiobalaenoptera’* sp. (IZIKO SAM 55001) | 5.3 | 5.0 | South Atlantic | Govender *et al.* (2016) |
| *Plesiobalaenoptera quarantellii* | 11.608 | 7.246 | Mediterranean | Bisconti (2010a) |
| *‘Marzanoptera’ bertae* | 3.35 | 2.5 | North Pacific | Boessenecker (2013) |
| *Parabalaenoptea baulinensis* | 7.246 | 5.332 | North Pacific | Zeigler *et al.* (1997) |
| *Fragilicetus velponi* | 5.332 | 5.0 | North Sea; South Atlantic | Bisconti & Bosselaers (2016); Govender (2019) |
| *‘Megaptera’ hubachi* | 5.332 | 3.6 | South Pacific | Bisconti (2011) |
| *Diunatans luctoretemergo* | 5.3 | 2.558 | North Sea | Bosselaers & Post (2010) |
| *‘Balaenoptera’ siberi* | 7.246 | 5.332 | South Pacific | Paleobiology Database |
| *Archaebalaenoptera eusebioi* | 8.85 | 7.93 | South Pacific | This work |
| MHNL M 1613 | 7.5 | 7.3 | South Pacific | Bisconti *et al.* (in prep. a) |
| MGPT UT PU13842/5 | 3.4 | 3.2 | Mediterranean | Caretto (1970) |
| *Archaebalaenoptera liesselensis* | 8.2 | 7.5 | North Sea | Bisconti *et al.* (in prep. b) |
| *Protororqualus wilfriedneesi* | 3.71 | 2.74 | North Sea | Bisconti & Bosselaers (2020) |
| NBC NMR 7096 | 3.7 | 2.7 | North Sea | Bisconti & Bosselaers (in prep.) |
| *Incakujira anillodefuego* | 7.5 | 7.3 | South Pacific | Marx & Kohno (2016) |
| *Megaptera novaeangliae* | 0.781 | 0.0 | North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean | Paleobiology Database;  |
| *‘Marzanoptera’ bertae* | 5.332 | 2.558 | North Pacific | Boessenecker (2013) |
| *Miobalaenoptera numataensis* | 6.8 | 6.5 | North Pacific | Tanaka & Watanabe (2019) |
| *‘Plesiobalaenoptera’ miocaena* | 11.608 | 7.246 | North Pacific | Paleobiology Database |
| Maesawa-Cho | 5.3 | 5.0 | North Pacific  | Oishi *et al.* (1985) |
| Shimajiri-kujira | 9.0 | 8.0 | North Pacific | Kimura *et al.* (2015) |
| *Balaenoptera borealis* | 2.6 | 0.0 | North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean | Paleobiology Database |
| *Balaenoptera edeni* | 0.012 | 0.0 | North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean | Paleobiology Database  |
| *Balaenoptera musculus* | 1.806 | 0.0 | North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean | Paleobiology Database |
| *Balaenoptera omurai* | 0.012 | 0.0 | North Pacific | Paleobiology Database |
| *Balaenoptera brydei* | 0.012 | 0.0 | North Pacific | Wada *et al.* (2007) |
| *Balaenoptera physalus* | 1.3 | 0.0 | North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean, Mediterranean | Paleobiology Database |
| *Balaenoptera acutorostrata* | 3.6 | 0.0 | North Atlantic, North Pacific, Mediterranean, Indian Ocean | Paleobiology Database |
| *Balaenoptera bonaerensis* | 0.012 | 0.0 | South Atlantic, South Pacific  | Paleobiology Database |

FO, first occurrence; LO, last occurrence. Data in Ma.

**Table S3**

**Matrix for palaeobiogeographic analysis**

*Eschrichtius* *robustus* 2

NBC RGM 630 1

*Eschrichtioides gastaldii* 0

*Archaeschrichtius ruggieroi* 0

IRSNB M2231 1

*‘Balaenoptera’ ryani* 2

*Protororqualus cuvieri* 0

*Protororqualus wilfriedneesi* 1

MGPT PU 13883 0

*‘Balaenoptera’ cortesii* var. *portisi* 0

NMR7096 1

*Marzanoptera tersillae* 0

*Plesiobalaenoptera quarantellii* 0

*Plesiobalaenoptera* sp. (IZIKO SAM55001) 3

*Parabalaenoptera baulinensis* 2

*Fragilicetus velponi* 1

*‘Plesiobalaenoptera’ hubachi* 4

*Incakujira anillodefuego* 4

MHNL M1613 4

*Archaebalaenoptera castriarquati* 0

*Archaebalaenoptera eusebioi* 4

*Archaebalaenoptera liesselensis* 1

*Nehalaennia devossi* 1

*‘Marzanoptera’ bertae* 2

Shimajiri-kujira 2

Maesawa-cho 2

*Miobalaenoptera numataensis* 2

*Diunatans luctoretemergo* 1

*Norrisanima miocaena* 2

*‘Balaenoptera’ siberi* 4

*Megaptera novaeangliae* 5

*Balaenoptera physalus* 5

*Balaenoptera acutorostrata* 5

*Balaenoptera bonaerensis* 5

*Balaenoptera omurai* 5

*Balaenoptera brydei* 5

*Balaenoptera edeni* 5

*Balaenoptera borealis* 5

*Balaenoptera musculus* 5

Character list: 0, Mediterranean; 1, North Atlantic; 2, North Pacific; 3, South Atlantic; 4, South Pacific; 5, cosmopolitan.

**Table S4**

**Proportions of the posterior portions of the dentary**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Family** | **species** | **repository** | **D(cond-cor)** | **D(cond-ang)** | **Ratio** | **Refs.** |
|  |  |  |  |  |  |  |
| Balaenopteridae | *Balaenoptera edeni* | IZIKO ZM12962 | 460 | 230 | 2 | 1 |
| Balaenopteridae | *Balaenoptera edeni* | IZIKO ZM12962 | 470 | 230 | 2.04 | 1 |
| Balaenopteridae | *Balaenoptera borealis* | NBC RGM31164 | 390 | 130 | 3 | 1 |
| Balaenopteridae | *Megaptera novaeangliae* | IZIKO ZM2288 | 3140 | 390 | 8.05 | 1 |
| Balaenopteridae | *Megaptera novaeangliae* | IZIKO ZM3978 | 1385 | 315 | 4.17 | 1 |
| Balaenopteridae | *Megaptera novaeangliae* | IZIKO ZM3978 | 1400 | 315 | 4.44 | 1 |
| Balaenopteridae  | *‘Balaenoptera’ cortesi* var. *portisi* † | MGPT PU 13808 | 280 | 144 | 1.9 | 1 |
| Balaenopteridae  | *Plesiobalaenoptera quarantellii* † | MuMAB 240505 | 355 | 104 | 3.41 | 1 |
| Balaenopteridae  | *Plesiobalaenoptera quarantellii* † | MuMAB 240505 | 420 | 150 | 2.8 | 2 |
| Balaenopteridae  | *Archaebalaenoptera eusebioi* † | MHNL 1610 | 206 | 63.4 | 3.24 | 1 |
| Eschrichtiidae | *Eschrichtioides gastaldii* † | MGPT PU 13802 | 200 | 138 | 1.45 | 1 |
| Basal thalassotherian | *Parietobalaena palmeri* † | USNM 12697 | 120.6 | 88 | 1.37 | 3 |
| Basal thalassotherian | *Parietobalaena palmeri* † | USNM 11535 | 158.1 | 98.4 | 1.61 | 3 |
| Basal thalassotherian | *Diorocetus hiatus* † | USNM 23494 | 212.9 | 175 | 1.21 | 3 |
| Basal thalassotherian | *Pelocetus calvertensis* † | USNM 11976 | 203.3 | 203.4 | 0.99 | 3 |
| Basal Cetotheriidae | *Titanocetus sammarinensis* † | MGGC 9071-9073 | 142 | 136 | 1.04 | 4 |
|  |  |  |  |  |  |  |

References: 1, this work; 2, Bisconti (2010); 3, Kellogg (1968); 4, Bisconti (2006).

Caption: cond, mandibular condyle; cor, coronoid process; D, distance; Ratio, [D(cond-cor)/D(cond-ang)]; †, fossil taxon.



**Fig. S1**

Distribution of character 101 (shape of glenoid fossa of the squamosal) across the mysticete phylogeny. State (0) glenoid fossa forming a right angle in lateral view; (1) Slightly concave; (2) Highly concave (crescent-shaped); (3) Straight. Colors as in the legend.



**Fig. S2**

Distribution of the synovial/intermediate/non-synovial joint types across mysticete phylogeny. Colors as in the legend.

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